

**The Associations Among Sleep Problems, Emotion Dysregulation
and Adjustment Over Time Among University Students**

by
Thalia Semplonius

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Department of Psychology
BROCK UNIVERSITY
St. Catharines, Ontario

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Abstract

Young adults experience a variety of changes when entering university (e.g., leaving home for the first time). Although some students adjust well to university, others may experience difficulties. Two problems that may be experienced are sleep problems and difficulties regulating emotion; importantly, both of these factors are associated with a variety of adjustment indicators. Throughout this dissertation, the three adjustment indicators that were of interest were physical activity, depressive symptoms and alcohol use as all three are common throughout university. As little work has examined the direction of effects between all of these factors, a longitudinal dataset was used to examine the relationships among these factors in two ways. Participants included 1132 first year undergraduate students (Time 1 $M_{age} = 19.06$ years, $SD = 11.17$ months). The first method was the use of a variable-centered analysis which was used in Studies 1 and 2. Study 1 focused on the relationships among sleep problems, emotion dysregulation, and physical activity and Study 2 focused on the relationships among sleep problems, emotion dysregulation, depressive symptoms, and alcohol use. Study 3 used a person-centered analysis which allowed for the examination of heterogeneity in the patterns of association between variables. Specifically, this study involved examining heterogeneity in the associations between sleep problems and emotion dysregulation, and how these patterns were related to depressive symptoms and alcohol use in both the short- and long-term. Overall, these studies indicate that sleep and emotion dysregulation are both bidirectionally related over time and also co-occur for a subgroup of individuals. The results also indicate that difficulties in adjustment experienced early on in university may have lasting effects.

Key words: emotion dysregulation; sleep problems; exercise; depression; alcohol

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Chapter 1 - General Introduction

Sleep quality is considered to be of great importance across the lifespan. Indeed, the National Sleep Foundation (NSF) has numerous articles outlining the importance of sleep quality in a variety of areas (e.g., sleep disorders, sleep problems, sleep for travel, sleep during pregnancy, insomnia, etc.; National Sleep Foundation, 2017). Given the focus of this dissertation on a sample of undergraduate students, my interests were mainly on the relationships between sleep problems and indicators of adjustment that are important throughout this period of life (albeit *also* important throughout the lifespan). The set of research studies included in this dissertation focus on three indicators of adjustment in particular: alcohol use, depressive symptoms, and physical activity. All three adjustment indicators are common problems among university students. Many students engage in less physical activity compared to the amount they engaged in throughout high school (Bray & Born, 2004; Deliens, Deforche, De Bourdeaudhuij, & Clarys, 2015), engage in high levels of binge drinking (Johnston, O'Malley, Bachman, & Schulenberg, 2007; Willoughby, Good, Adachi, Hamza, & Tavernier, 2013), and report mental health problems (e.g., depression) (Center for Behavioral Health Statistics and Quality, 2015; Pearson, Janz, & Ali, 2013).

Past research has indicated that sleep problems are associated with lower physical activity (e.g., Brand et al., 2010; Gerber, Brand, Holsboer-Trachsler, & Pühse, 2010), depressive symptoms (e.g., Armstrong & Oomen-Early, 2009; Conti, Adams, & Kisler, 2014), and alcohol use (e.g., DeMartini & Fucito, 2014; Digdon & Landry, 2013), but the majority of this work tends to be concurrent or cross-sectional, which does not provide information on temporal precedence (i.e., whether sleep is a predictor or an outcome).

Little longitudinal work has examined these associations across time. Conducting longitudinal research in this area can help address issues of temporal precedence, as well as identify potential mechanisms for *how* sleep is associated with adjustment over time.

Throughout my dissertation, I focus on the role of emotion dysregulation as a mechanism through which sleep problems may be associated with adjustment in university. Emotion regulation is defined by Gross (1998) as "...the processes by which individuals influence which emotions they have, when they have them, and how they experience and express these emotions." (p. 275). Thus, emotion dysregulation is being unable to use these regulatory processes to modulate emotional responses effectively. More specifically, Carpenter and Trull (2013) define it as, "...the inability to flexibly respond to and manage emotions," (p. 1). In this thesis, the focus is on regulating emotions when one is upset or stressed. The ability to regulate emotions is associated with numerous factors that are related to well-being both concurrently and over time (e.g., social ties, experiencing positive affect, self-esteem, and life satisfaction; Gross & John, 2003; Semplonius, Good, & Willoughby, 2014; Tavernier & Willoughby, 2014). Furthermore, emotion dysregulation has been linked to sleep problems (e.g., Cerolini, Balleio, & Lombardo, 2015), physical activity (e.g., Ready, Marquez, & Akerstedt, 2009), alcohol use (e.g., Messman-Moore, Ward, Zerubavel, Chandley, & Barton, 2015), and depressive symptoms (e.g., Markarian, Pickett, Deveson, & Kanona, 2013). Few research studies, however, have examined these associations across time.

Thus, two areas of interest that are pertinent to my dissertation is the examination of long-term associations between sleep problems and emotion dysregulation, and how sleep problems and emotion dysregulation are associated with indicators of adjustment

over time. To address these issues, I conducted three studies. I am first author on each of these papers which indicates that I took a lead role in each project idea and conceptualization, the data analysis (both independently and with my supervisor, Dr. Willoughby), and in the writing of the first draft of each manuscript.

Theoretical Models

Given the focus on emotion dysregulation as a mechanism, it is important to understand how sleep problems and emotion dysregulation are related. In a recent review, Vandekerckhove and Wang (2017) discussed how the relationship between sleep and emotions/emotion dysregulation is complex and that much more work has to be conducted in this area to fully understand this association. Throughout the literature, however, a few models have been proposed for how sleep and emotion dysregulation may be linked. The first is the Attention-Intention-Effort Pathway (Espie, Broomfield, Macmahon, Macphee, & Taylor, 2006). The second model was developed in a recent review paper by Palmer and Alfano (2017) in which the authors integrate Gross' (2002) process model for emotion dysregulation with sleep. The final model provides a mechanism by which sleep may impact on emotional processing (Yoo, Gujar, Hu, Jolesz, & Walker, 2007).

Attention-Intention-Effort Pathway. Espie et al. (2006) provide a model (see Figure 1-1) which integrates factors that are related to the development of *psychophysiologic insomnia* (an insomnia subtype most relevant to difficulties initiating sleep). Although my research area does not specifically examine insomnia as a clinical measure, this model is one way of understanding how sleep problems may be related to emotion dysregulation. First, the authors relate *selective attention* to insomnia. Briefly, individuals

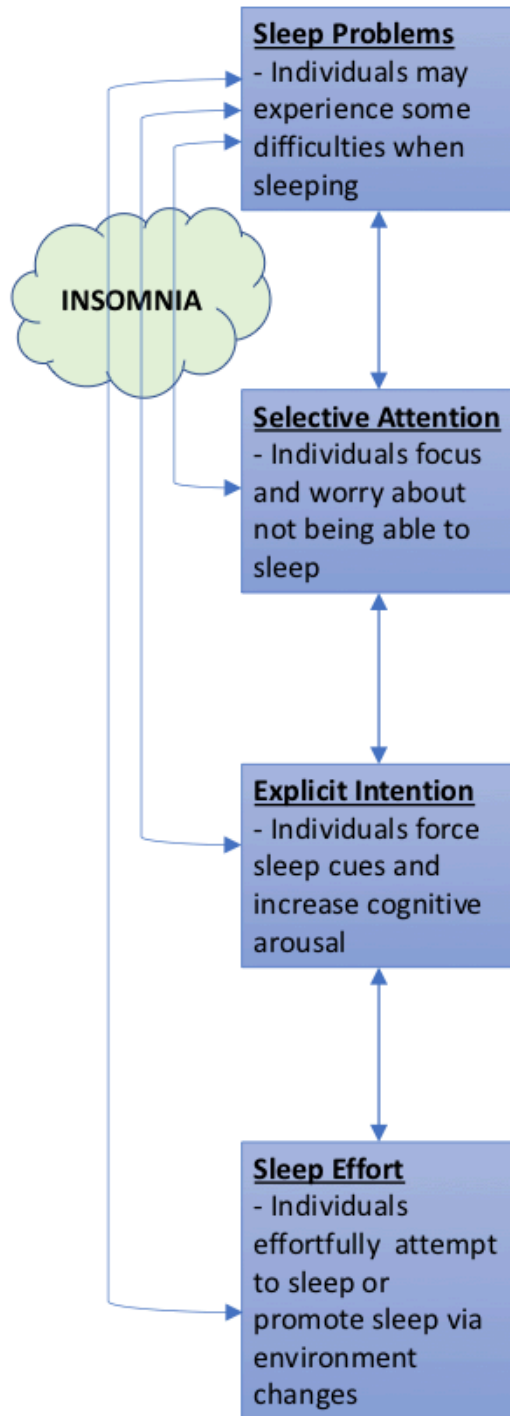


Figure 1-1. Attention-Intention-Effort Pathway model adapted from Broomfield and Espie (2005). This model demonstrates that these pathways to maintaining insomnia symptoms can be reinforcing.

may focus their attention on sleep or worrying about not being able to sleep well, thereby resulting in poor sleep quality (Espie et al., 2006). Next, the authors outline *explicit intention* and its relation to insomnia. Individuals with healthy sleep may engage in routine and automatic behaviours to start their sleep process, whereas those with insomnia may try to explicitly force sleep cues. Espie et al. (2006) note that trying to force these sleep cues creates more cognitive arousal which can result in problems going to sleep. Finally, *sleep effort* is the process of actually sleeping. For example, individuals can exert energy on actually falling asleep (e.g., lying in bed trying to actually fall asleep), or by exerting effort on their surroundings to try and promote sleep (e.g., going to bed earlier to try and increase the chance of sleeping; Espie, 2006). However, Espie indicates that in the long run, both of these sleep effort practices can actually inhibit sleep even if there may be initial benefits.

This framework suggests that cognitive factors are of great importance to sleep quality. It may be that the inability to regulate emotions increases cognitive load (Deveney & Pizzagalli, 2008) and, as a result, impedes sleep. Indeed, in a sample of young adult low-SES women, experiencing negative emotions predicted poor sleep quality both directly and indirectly through emotion dysregulation (positive emotions only indirectly predicted sleep quality via emotion dysregulation; Hoag, Tennen, Stevens, Coman, & Wu, 2016).

Integrated Process Model of Emotion Regulation. A recent review paper by Palmer and Alfano (2017) integrated sleep with Gross' (2002) process model for emotion dysregulation. In the process model, Gross (2002) indicated that emotional responses to our experiences can occur in two ways. We can either deal with an emotion or an

emotional experience before it has occurred (i.e., “antecedent-focused regulation”; for example, reframing a future situation into a positive light so as to lessen anxiety) or after it has occurred (i.e., “response-focused regulation”; for example, downplaying the anxiety you may currently be feeling; See Figure 1-2). Gross (2002) indicates that antecedent processing has four components: 1) *situation selection*, in which individuals choose whether or not to engage in a certain emotionally-evoking situation, 2) *situation modification*, in which individuals may change their perspective about the situation with the goal of adjusting their emotional experiences, 3) *attentional deployment*, in which individuals either attend to – or do not attend to – the emotionally-evoking stimulus, and 4) *cognitive change*, in which individuals alter the emotionally-evocative stimuli’s meaning. Response-focused emotion regulation is comprised only of one stage – *response modulation*. As the name suggest, this is when individuals alter the manner in which their emotions are displayed after already experiencing the emotion (Gross, 2002).

Palmer and Alfano (2017) have taken Gross’ process model and linked each module to previous sleep research. In their review, Palmer and Alfano (2017) indicate that individuals with poor sleep tend to 1) engage in different situations (e.g., engage in fewer social activities) than individuals with good sleep patterns (e.g., Carney, Edinger, Meyer, Lindman, & Istre, 2006), 2) have difficulties modifying situations in positive ways (e.g., Gordon & Chen, 2014), and 3) are more reactive and attend more to negative stimuli than to positive stimuli (e.g., Yoo et al., 2007). Palmer and Alfano suggest that one area that appears to be less affected by sleep is stage 4 of the process model – *cognitive change*. They indicate that past research examining associations between sleep and cognitive

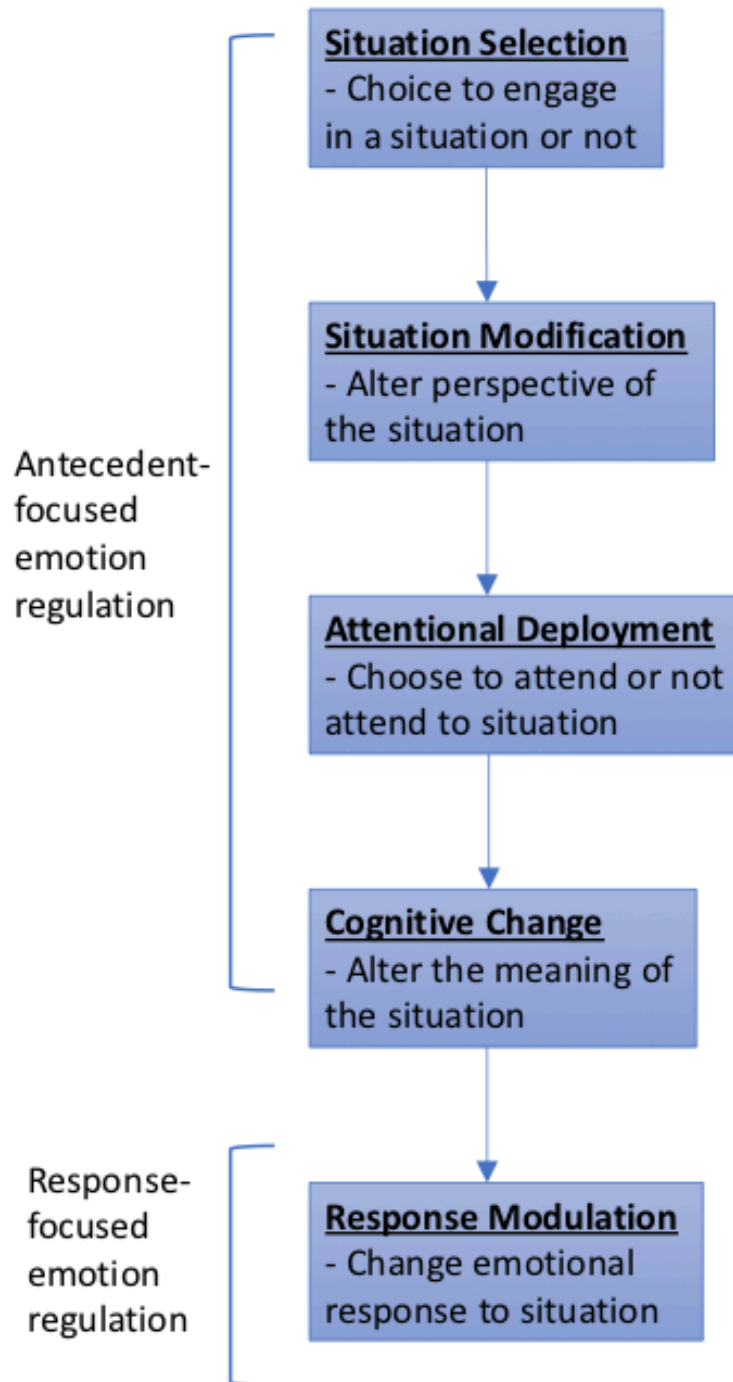


Figure 1-2. Process model of emotion dysregulation adapted from Gross (2002).

reappraisal are mixed, with some research finding links between sleep problems and difficulties reappraising (e.g., Mauss, Troy, & LeBourgeois, 2013) and other research finding that sleep-deprived individuals who use cognitive reappraisal frequently attend less to negative stimuli than sleep deprived individuals using this strategy less frequently (e.g., Cote, Jancsar, & Hunt, 2015). Palmer and Alfano conclude that research examining response modulation is limited and results are unclear as to how sleep is associated with this stage of the process model.

Emotional Processing. An emotional processing model of the relationship between sleep and emotion dysregulation is based on a study conducted by Yoo, Gujar, Hu, Jolesz, and Walker (2007). Yoo et al. set out to examine whether sleep deprivation is associated with problems processing emotional stimuli based on two neural networks: the amygdala and prefrontal cortex. These neural networks were chosen as emotions are generally processed and regulated by the amygdala and the pre-frontal cortex (for a review see Beer & Lombardo, 2007). Yoo et al. focused on this neural network in two groups of adults: a sleep-deprived group and a control group.

On the first day of the experiment, participants were divided into either the sleep deprivation group (who stayed awake the entire following night) or the control group (who slept normally). The next day, participants were shown a set of emotional stimuli and were asked to indicate the emotion on each face while being scanned with fMRI. Yoo et al. (2007) found that when viewing negative stimuli, sleep-deprived individuals displayed more reactivity in their amygdala and less prefrontal cortex activity than the control group. Yoo et al. 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 both increased reactivity to negative emotions and a decreased ability to regulate these emotional responses (i.e., emotion dysregulation).

Sleep, Emotion Dysregulation and Adjustment

Although these models provide ways in which the relationship between sleep problems and emotion dysregulation are associated, my goal was not to specifically test these theories. Rather, they are used in this dissertation to help explain *why* and *how* these factors are related. For example, sleep problems could predict emotion dysregulation because sleep may alter the manner in which emotions are processed, and/or emotion dysregulation could predict sleep problems because the inability to effectively cope with emotions may increase cognitive arousal and impede sleep initiation.

I had two overarching goals in my dissertation. The first goal was to examine how sleep problems and emotion dysregulation are related to psychosocial adjustment in the short- and long-term. I addressed this goal in Studies 1 and 2 in which I examined the relationships among sleep problems, emotion dysregulation, and physical activity across three years of university (Study 1) and among sleep problems, emotion dysregulation, depressive symptoms, and alcohol use (Study 2) over five years, starting when students were in their first year of university.

The second goal was to examine individual differences in the associations between sleep problems and emotion dysregulation, given that these factors tend to be indicators of a variety of mental health problems (Fairholme et al., 2013a). For example, individuals could have different patterns of association in the relationship between sleep problems and emotion dysregulation (e.g., individuals could display high levels of both or just one factor). Therefore, I examined how these patterns of association between sleep

problems and emotion dysregulation are related to alcohol use and depressive symptoms given their prevalence throughout university (Center for Behavioral Health Statistics and Quality, 2015; Johnston et al., 2007; Pearson et al., 2013; Willoughby et al., 2013). I addressed this goal in Study 3 in which I conducted a latent class analysis to ascertain how individuals differ in their associations between sleep problems and emotion dysregulation. Outlined below is a summary of each of the studies and their contributions to the research field.

Summary of the Present Studies

Study 1. Past research has been inconsistent in its examination of the relationship between sleep problems and physical activity. One of the reasons for this inconsistency is the model or research question used to address this association. I addressed the issue in Study 1. In the past, researchers have tended to frame their research questions as “one-sided” examinations into the association between sleep problems and physical activity. In other words, researchers have examined 1) the impact of sleep problems on physical activity (Garaulet et al., 2011; Martin, 1981; Schmid et al., 2009), or 2) the impact of physical activity on sleep (Brand et al., 2014; Myllymäki et al., 2011; Youngstedt, Kripke, & Elliott, 1999). This has resulted in a plethora of mixed findings as to what is the relationship between sleep and physical activity. Indeed, the direction of effects between sleep and physical activity is unclear. Inconsistent findings also suggest that there may be potential mechanisms through which sleep and physical activity are related.

In Study 1, therefore, I had two goals. The first was to examine the longitudinal relationship between sleep problems and physical activity. The second was to examine a potential mechanism by which sleep and physical activity are related, namely, the role of

emotion dysregulation. Using an autoregressive cross-lag path analysis in this study allowed me to test both the direction of effects across time, and indirect effects – or potential mechanisms – by which they may be related.

Study 2. Past research has indicated that sleep problems and emotion dysregulation are related (see Cerolini et al., 2015), but little work has examined the direction of effects between these two factors. Further, both sleep and emotion dysregulation are associated with alcohol use (e.g., Digdon & Landry, 2013; Dragan, 2015) and depressive symptoms (e.g., Conti et al., 2014; Nolen-Hoeksema & Aldao, 2011), two adjustment indicators that are important throughout university. In the second study of my dissertation, there were three goals. The first was to examine the potential bidirectional association between sleep problems and emotion dysregulation. The second was to examine short- and long-term associations between sleep problems and emotion dysregulation, as well as depressive symptoms and alcohol use. The third goal was to examine whether emotion dysregulation is a mechanism through which sleep is associated with both depressive symptoms and alcohol use over time.

Using an autoregressive cross-lag path analysis in this study allowed me to examine short- and long-term associations among sleep problems, emotion dysregulation, and the two adjustment indicators. Overall, this study allowed me to address gaps in the literature by providing a comprehensive, longitudinal model that allows for the examination of temporal order between indicators that are important for university students.

Study 3. Given the nature of the association between sleep problems and emotion dysregulation (as Studies 1 and 2 indicated there was a bidirectional association between

these two factors) and the fact that they tend to be transdiagnostic (i.e., they are common indicators of many health problems; Fairholme et al., 2013), the first goal of the third study of my dissertation was to examine whether there are groups of people with different patterns of association between sleep problems and emotion dysregulation. The second goal was to examine whether these patterns of association were differentially related to depressive symptoms and alcohol use in both the short- and long-term.

To address the first goal, a latent class analysis was conducted to examine heterogeneity in the associations between sleep problems and emotion dysregulation. To address the second goal, MANOVAs were conducted to examine group differences on depressive symptoms and alcohol use in both the short- and long-term (i.e., four years later). This allowed me to specifically examine whether different patterns of association of these difficulties are related to the two adjustment indicators.

References

- Armstrong, S., & Oomen-Early, J. (2009). Social connectedness, self-esteem, and depression symptomatology among collegiate athletes versus nonathletes. *Journal of American College Health, 57*(5), 521–526. <https://doi.org/10.3200/JACH.57.5.521-526>
- Beer, J. S., & Lombardo, M. V. (2007). Insights into Emotion Regulation from Neuropsychology. In J. J. Gross (Ed.), *Handbook of Emotion Regulation* (1st ed., pp. 69–86). New York, NY: The Guilford Press.
- Brand, S., Gerber, M., Beck, J., Hatzinger, M., Pühse, U., & Holsboer-Trachsler, E. (2010). Exercising, sleep-EEG patterns, and psychological functioning are related among adolescents. *The World Journal of Biological Psychiatry, 11*, 129–140. <https://doi.org/10.3109/15622970903522501>
- Brand, S., Kalak, N., Gerber, M., Kirov, R., Pühse, U., & Holsboer-Trachsler, E. (2014). High self-perceived exercise exertion before bedtime is associated with greater objectively assessed sleep efficiency. *Sleep Medicine, 15*, 1031–1036. <https://doi.org/10.1016/j.sleep.2014.05.016>
- Bray, S. R., & Born, H. A. (2004). Transition to University and Vigorous Physical Activity: Implications for Health and Psychological Well-Being. *Journal of American College Health, 52*(June), 181–188. <https://doi.org/10.3200/JACH.52.4.181-188>
- Broomfield, N. M., & Espie, C. A. (2005). Towards a valid, reliable measure of sleep effort. *Journal of Sleep Research, 14*(4), 401–407. <https://doi.org/10.1111/j.1365-2869.2005.00481.x>

- Carney, C. E., Edinger, J. D., Meyer, B., Lindman, L., & Istre, T. (2006). Daily activities and sleep quality in college students. *Chronobiology International*, *23*(3), 623–637. <https://doi.org/10.1080/07420520600650695>
- Carpenter, R. W., & Trull, T. J. (2013). Components of emotion dysregulation in borderline personality disorder: A review. *Curr Psychiatry Rep*, *15*(1), doi: 10.1007/s11920-012-0335-2
- Center for Behavioral Health Statistics and Quality. (2015). *Behavioral health trends in the United States: Results from the 2014 National Survey on Drug Use and Health*. Retrieved from <http://www.samhsa.gov/data/>
- Cerolini, S., Ballesio, A., & Lombardo, C. (2015). Insomnia and emotion regulation: Recent findings and suggestions for treatment. *Journal of Sleep Disorders and Management*, *1*(1), 1–5.
- Conti, J. R., Adams, S. K., & Kisler, T. S. (2014). A pilot examination of self-esteem, depression, and sleep in college women. *NASPA Journal About Women in Higher Education*, *7*(1), 47–72. <https://doi.org/10.1515/njawhe-2014-0004>
- Cote, K., Jancsar, C., & Hunt, B. (2015). Event-related neural response to emotional picture stimuli following sleep deprivation. *Psychology and Neuroscience*, *8*(1), 102–113. <https://doi.org/10.1037/h0100354>
- Deliens, T., Deforche, B., De Bourdeaudhuij, I., & Clarys, P. (2015). Determinants of physical activity and sedentary behaviour in university students: a qualitative study using focus group discussions. *BMC Public Health*, *15*, 201. <https://doi.org/10.1186/s12889-015-1553-4>
- DeMartini, K. S., & Fucito, L. M. (2014). Variations in sleep characteristics and sleep-

- related impairment in at-risk college drinkers: A latent profile analysis. *Health Psychology, 33*(10), 1164–1173. <https://doi.org/10.1037/hea0000115>
- Deveney, C. M., & Pizzagalli, D. A. (2008). The cognitive consequences of emotion regulation: An ERP investigation. *Psychophysiology, 45*(3), 435–444. <https://doi.org/10.1109/TMI.2012.2196707>. Separate
- Digdon, N., & Landry, K. (2013). University students' motives for drinking alcohol are related to evening preference, poor sleep, and ways of coping with stress. *Biological Rhythm Research, 44*(1), 1–11. <https://doi.org/10.1080/09291016.2011.632235>
- Dragan, M. (2015). Difficulties in emotion regulation and problem drinking in young women: The mediating effect of metacognitions about alcohol use. *Addictive Behaviors, 48*, 30–35. <https://doi.org/10.1016/j.addbeh.2015.04.008>
- Espie, C. A., Broomfield, N. M., Macmahon, K. M. A., Macphee, L. M., & Taylor, L. M. (2006). The attention-intention-effort pathway in the development of psychophysiologic insomnia: A theoretical review. *Sleep Medicine Reviews, 10*, 215–245. <https://doi.org/10.1016/j.smr.2006.03.002>
- Fairholme, C. P., Nosen, E. L., Nillni, Y. I., Schumacher, J. A., Tull, M. T., & Coffey, S. F. (2013a). Sleep disturbance and emotion dysregulation as transdiagnostic processes in a comorbid sample. *Behaviour Research and Therapy, 51*, 540–546. <https://doi.org/10.1016/j.brat.2013.05.014>
- Fairholme, C. P., Nosen, E. L., Nillni, Y. I., Schumacher, J. A., Tull, M. T., & Coffey, S. F. (2013b). Sleep disturbance and emotion dysregulation as transdiagnostic processes in a comorbid sample. *Behaviour Research and Therapy, 51*(9), 540–546. <https://doi.org/10.1016/j.brat.2013.05.014>

- Garaulet, M., Ortega, F. B., Ruiz, J. R., Rey-López, J. P., Béghin, L., Manios, Y., ... Moreno, L. A. (2011). Short sleep duration is associated with increased obesity markers in European adolescents: Effect of physical activity and dietary habits. The HELENA study. *International Journal of Obesity*, *35*, 1308–1317. <https://doi.org/10.1038/ijo.2011.149>
- Gerber, M., Brand, S., Holsboer-Trachsler, E., & Pühse, U. (2010). Fitness and exercise as correlates of sleep complaints: Is it all in our minds? *Medicine & Science in Sports & Exercise*, *42*(5), 893–901. <https://doi.org/10.1249/MSS.0b013e3181c0ea8c>
- Gordon, A. M., & Chen, S. (2014). The role of sleep in interpersonal conflict: Do sleepless nights mean worse fights? *Social Psychological and Personality Science*, *5*(2), 168–175. <https://doi.org/10.1177/1948550613488952>
- Gross, J. J. (1998). The emerging field of emotion regulation: An integrative review. *General Review in Psychology*, *2*(3), 271–299.
- Gross, J. J. (2002). Emotion regulation: Affective, cognitive, and social consequences. *Psychophysiology*, *39*, 281–291. <https://doi.org/10.1017.S0048577201393198>
- Gross, J. J., & John, O. P. (2003). Individual differences in two emotion regulation processes: Implications for affect, relationships, and well-being. *Journal of Personality and Social Psychology*, *85*(2), 348–362. <https://doi.org/10.1037/0022-3514.85.2.348>
- Harvey, A. G. (2002). A cognitive model of insomnia. *Behaviour Research and Therapy*, *40*, 869–893.
- Hoag, J. R., Tennen, H., Stevens, R. G., Coman, E., & Wu, H. (2016). Affect, emotion dysregulation and sleep quality among low-income women. *Sleep Health*, *2*(4), 283–

288. <https://doi.org/10.1126/science.1249098>.Sleep

Johnston, L. D., O'Malley, P. M., Bachman, J. G., & Schulenberg, J. E. (2007).

Monitoring the Future: National Survey Results on Drug Use, 1975-2006 - Volume I, Secondary School Students. Monitoring the Future (Vol. I). Bethesda, MD.

Retrieved from http://monitoringthefuture.org/pubs/monographs/vol1_2006.pdf

Markarian, S. A., Pickett, S. M., Deveson, D. F., & Kanona, B. B. (2013). A model of BIS/BAS sensitivity, emotion regulation difficulties, and depression, anxiety, and stress symptoms in relation to sleep quality. *Psychiatry Research, 210*(1), 281–286.

<https://doi.org/10.1016/j.psychres.2013.06.004>

Martin, B. J. (1981). Effect of sleep deprivation on tolerance of prolonged exercise.

European Journal of Applied Physiology, 47, 345–354.

Mauss, I. B., Troy, A. S., & LeBourgeois, M. K. (2013). Poorer sleep quality is

associated with lower emotion-regulation ability in a laboratory paradigm. *Cognition & Emotion, 27*(3), 1–10. <https://doi.org/10.1080/02699931.2012.727783>

Messman-Moore, T., Ward, R. M., Zerubavel, N., Chandley, R. B., & Barton, S. N.

(2015). Emotion dysregulation and drinking to cope as predictors and consequences of alcohol-involved sexual assault: Examination of short-term and long-term risk.

Journal of Interpersonal Violence, 30(4), 601–621.

<https://doi.org/10.1177/0886260514535259>

Myllymäki, T., Kyröläinen, H., Savolainen, K., Hokka, L., Jakonen, R., Juuti, T., ...

Rusko, H. (2011). Effects of vigorous late-night exercise on sleep quality and cardiac autonomic activity. *Journal of Sleep Research, 20*(1 PART II), 146–153.

<https://doi.org/10.1111/j.1365-2869.2010.00874.x>

- National Sleep Foundation. (2017). Retrieved June 7, 2017, from <https://sleepfoundation.org/>
- Nolen-Hoeksema, S., & Aldao, A. (2011). Gender and age differences in emotion regulation strategies and their relationship to depressive symptoms. *Personality and Individual Differences, 51*(6), 704–708. <https://doi.org/10.1016/j.paid.2011.06.012>
- Palmer, C. A., & Alfano, C. A. (2017). Sleep and emotion regulation: An organizing, integrative review. *Sleep Medicine Reviews, 31*, 6–16. <https://doi.org/10.1016/j.smr.2015.12.006>
- Pearson, C., Janz, T., & Ali, J. (2013). *Health at a glance: Mental and substance use disorders in Canada. Statistics Canada*. Retrieved from <http://www.statcan.gc.ca/pub/82-624-x/2013001/article/11855-eng.pdf>
- Ready, R. E., Marquez, D. X., & Akerstedt, A. (2009). Emotion in younger and older adults: Retrospective and prospective associations with sleep and physical activity. *Experimental Aging Research, 35*(3), 348–368. <https://doi.org/10.1080/03610730902922184>
- Schmid, S. M., Hallschmid, M., Jauch-Chara, K., Wilms, B., Benedict, C., Lehnert, H., ... Schultes, B. (2009). Short-term sleep loss decreases physical activity under free-living conditions but does not increase food intake under time-deprived laboratory conditions in healthy men. *American Journal of Clinical Nutrition, 90*(6), 1476–1482. <https://doi.org/10.3945/ajcn.2009.27984>
- Semplonius, T., Good, M., & Willoughby, T. (2014). Religious and Non-religious Activity Engagement as Assets in Promoting Social Ties Throughout University: The Role of Emotion Regulation. *Journal of Youth and Adolescence*.

<https://doi.org/10.1007/s10964-014-0200-1>

Tavernier, R., & Willoughby, T. (2014). A longitudinal examination of the bidirectional association between sleep problems and social ties at university: The mediating role of emotion regulation. *Journal of Youth and Adolescence*, 1–14.

<https://doi.org/10.1007/s10964-014-0107-x>

Vandekerckhove, M., & Wang, Y. (2017). Emotion, emotion regulation and sleep: An intimate relationship. *AIMS Neuroscience*, 5(1), 1–17.

<https://doi.org/10.3934/Neuroscience.2018.1.1>

Willoughby, T., Good, M., Adachi, P. J. C., Hamza, C., & Tavernier, R. (2013).

Examining the link between adolescent brain development and risk taking from a social-developmental perspective. *Brain and Cognition*, 83(3), 315–324.

<https://doi.org/10.1016/j.bandc.2013.09.008>

Yoo, S. S., Gujar, N., Hu, P., Jolesz, F. a., & Walker, M. P. (2007). The human emotional brain without sleep - a prefrontal amygdala disconnect. *Current Biology*, 17(20),

877–878. <https://doi.org/10.1016/j.cub.2007.08.007>

Youngstedt, S. D., Kripke, D. F., & Elliott, J. A. (1999). Is sleep disturbed by vigorous late-night exercise? *Medicine and Science in Sports and Exercise*, 31(6), 864–9.

Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/10378914>

Chapter 2 - The direction of effects in the link between physical activity and sleep quality¹

Sleep experts (e.g., National Sleep Foundation, Centers for Disease Control and Prevention) and popular culture (Rampton, 2015) have inundated us with the idea that engaging in physical activity can promote better sleep. In fact, a quick Google search with the question, “Can exercise make you sleep better?” leads to many sites that tell us that, yes, it can. Findings from research examining this relationship, however, are mixed, with some studies finding a significant association and others not (Youngstedt, 2005). For example, Youngstedt et al. (2003) measured sleep and physical activity in undergraduates (using self-reported exercise and sleep diaries) and adults (using actigraphy and diaries), and found that there were no significant correlations between sleep and physical activity (see also Mitchell et al., 2016). Reasons for the mixed results (i.e., some researchers finding associations whereas others have not) may be the manner in which the studies are conducted and how the research question is framed. The majority of studies examining the associations between sleep and physical activity are cross-sectional, quasi-experimental or experimental, with researchers examining only *one* direction of associations. For example, researchers examine either 1) the effect of physical activity on sleep (Brand et al., 2010a, 2010b, 2014, 2016; Buman, Phillips, Youngstedt, Kline, & Hirshkowitz, 2014; Gerber, Brand, Holsboer-Trachsler, & Pühse, 2010; Myllymäki et al., 2011, 2012; O’Connor, Breus, & Youngstedt, 1998; Youngstedt, Kripke, & Elliott,

¹ The content of this chapter has been revised and resubmitted to *Medicine & Science in Sports & Exercise*.

1999), or 2) the effect of poor sleep/sleep deprivation on exercise (Garaulet et al., 2011; Martin, 1981; Schmid et al., 2009; Weaver et al., 1997).

Findings from research examining the effects of physical activity on sleep are mixed. Myllymäki et al. (2011) had 11 participants engage in one day with late-night exercise and another day with no late-night exercise and observed their sleep on those nights in a lab. Participants' reported sleep quality did not differ depending on whether they had exercised (the only finding was that there was less REM sleep after exercising). Similarly, Myllymäki et al. (2012) found no effect of varying intensity of physical activity on 14 male participants' sleep quality compared to days with no physical activity (for similar results see O'Connor et al., 1998; Youngstedt et al., 1999). In contrast, others *have* found significant effects of physical activity on sleep. Group comparison research with adolescents (non-random group assignment) revealed that 258 athletes reported better sleep quality than 176 non-athletes (Brand et al., 2010b), and 17 adolescents who exercised for ~8 hours a week had better objective sleep quality (measured through EEG) than 21 adolescents who exercised ~2 hours a week (although these non-randomized groups did not differ on subjective sleep quality; Brand et al., 2010a). Furthermore, in a study of 862 undergraduates, students who thought they were less active or less in shape concurrently reported poorer perceived sleep quality than students who perceived themselves as being more active and more in shape (Gerber et al., 2010). An experimental/longitudinal study by Kalak et al. (2012), using random assignment, examined whether 27 adolescents who ran for 30 minutes in the morning for three weeks showed more improvements in sleep than 24 individuals who did not run in the morning.

Kalak et al. (2012) found that both objective (EEG measurement) and subjective sleep quality improved only for those who ran for 30 minutes during weekday mornings.

There has been less research specifically examining the alternate direction of effects; that is, whether sleep influences subsequent physical activity (Weaver et al., 1997). Generally, research examining this direction of effects has used experimental designs. For example, Martin (1981) twice had 8 participants walk on treadmills until they were exhausted – once after a normal night of sleep and once after 36 hours of sleep deprivation. Martin (1981) found that physiological differences (e.g., heart rate) were minimal but participants' perceptions of how hard they had exercised were higher after sleep deprivation than after normal sleep, and they also exercised for less time after sleep deprivation. Schmid et al. (2009) found similar results such that 15 males who were sleep restricted engaged in less physical activity and less strenuous physical activity than when they had regular sleep. Furthermore, adolescents who reported sleeping less than 8 hours a night engaged in more sedentary behaviours than those who reported sleeping for longer periods of time (however, there were no differences in their moderate/vigorous physical activity levels; Garaulet et al., 2011).

Conclusions about the direction of effects in the association between sleep and physical activity, however, require the use of a longitudinal design in which *both* temporal order and bidirectionality can be assessed. Only two studies have directly assessed the bidirectional association between sleep and physical activity, and they were conducted with older adults. In a two-year longitudinal study of 489 older adults ($M_{age} = 72$ years; 87% retention), Holfeld and Ruthig (2014) found that sleep quality predicted more frequent physical activity over time, but physical activity did not predict better

sleep quality over time. In contrast, Dzierzewski et al. (2014) found a bidirectional relationship between sleep quality and exercise in an 18-week, daily diary study of 79 older adults ($M_{age} = 63$ years). Given these conflicting results and the focus only on older adults, the first goal of the present study was to investigate the bidirectional association between sleep and physical activity in a longitudinal study with university students. The transition from high school to university often is associated with decreased physical activity (Bray & Born, 2004; Deliens, Deforche, De Bourdeaudhuij, & Clarys, 2015) and changes in sleep (e.g., more wake time variability in university than high school; Doane, Gress-Smith, & Breitenstein, 2015; Urner, Tornic, & Bloch, 2009) making studies of this age period important for health promotion.

As not all studies have found a direct association between sleep and physical activity, there is some speculation that the effect between sleep and physical activity may be indirect. For example, physical activity has been hypothesized to promote better psychosocial adjustment (Brand et al., 2010a) such as emotion regulation, which in turn is thought to lead to better sleep; alternatively, exercise could promote sleep and, therefore, wellbeing (Biddle & Mutrie, 2008). Importantly, previous research has indicated that emotion regulation is tied to both physical activity (Ready, Marquez, & Akerstedt, 2009) and sleep (Tavernier & Willoughby, 2014). The second goal of the current study, therefore, was to examine whether emotion regulation mediates the relationship between physical activity and sleep quality over time (i.e., does physical activity promote better emotion regulation over time, and in turn, better sleep quality over time, and vice versa).

Method

Participants

The participants were 827 students enrolled at a mid-sized university in southern Ontario, Canada, who took part in a larger longitudinal study that started when they were in their first year of university. On average, during the first wave of data collection (i.e., Time 1), participants were 19.04 years old ($SD = .92$ years, range 17.75–25.51 years). The sample comprised 611 (73.88%) females, and 703 (85.01%) were born in Canada. Descriptive statistics are listed in Table 2-1. 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.*” Students were surveyed annually. Only data for the second, third and fourth waves are included in this study as sports team involvement was not assessed in the first wave.

Procedure

University students from various academic disciplines were invited to complete a survey examining factors related to stress, coping, and adjustment to university and were given course credit or monetary compensation for their participation at each time point. All students who participated in the first assessment were invited to participate again at each subsequent time point by way of e-mails, posters, and classroom announcements. At all assessments, the surveys were completed during the winter term. The University Ethics Board approved the study, and all participants provided informed consent prior to participation.

Missing Data Analyses

Missing data occurred within each assessment time point because some students did not answer every question (average missing data at Times 2, 3, and 4 were 1.971%, 1.914%, and 1.935% respectively) and because some students did not complete all three waves of the survey (retention rate was 83.9%; Time 2 $N = 827$, Time 3 $N = 714$, Time 4 $N = 694$). At Time 2, missingness was associated with sex, $F(2, 765) = 7.372, p = .001, \eta^2 = .019$; participants who completed three waves were more likely to be female than those who completed two waves, $M_{diff} = .172$ [95% CI .057 - .278], $SE = .049, p = .002$, or one wave, $M_{diff} = .157$ [95% CI .004 - .310], $SE = .064, p = .043$. Missingness also was associated with moderate physical activity, $F(2, 765) = 3.6720, p = .027, \eta^2 = .009$; participants who completed one wave reported less frequent moderate exercise than individuals who completed three waves, $M_{diff} = .377$ [95% CI .003 - .750], $SE = .156, p = .048$. Missingness was not associated with Time 3 or 4 study variables. Missing data were imputed using the EM (expectation-maximization) algorithm with all study measures included in the imputation process (Little, 2013). Methodological research has demonstrated that this method of dealing with missing data is preferable to more common methods such as pair-wise deletion, list-wise deletion, or mean substitution (Schafer & Graham, 2002).

Measures

All measures with the exception of demographics were assessed across three years of university. Sports club involvement also was assessed to control for any specific team benefits beyond physical activity.

Demographics. Self-reported sex, parental education (one item per parent,

averaged for participants reporting on both parents), and whether participants were born in Canada were assessed at Time 1 and used as covariates in all analyses.

Emotion regulation. Emotion regulation was assessed using six items from the Difficulties in Emotion Regulation Scale (Gratz & Roemer, 2004). The responses were based on a five-point Likert scale ranging from 1 (*almost never*) to 5 (*almost always*). Cronbach's alpha at Times 2, 3, and 4 were .74, .76, and .78, respectively. Higher scores indicated poorer emotion regulation.

Sleep quality. Sleep quality was assessed using an adapted version of the Insomnia Severity Index (Morin, 1993). As response options for items 1-5 ranged from 1 to 5 and item 6 response options ranged from 1 to 4, item 6 was recoded to have a range of 1 to 5 so a composite sleep variable could be created. Cronbach's alpha for the sleep items at Times 2, 3, and 4 were .77, .79, and .79, respectively. Higher scores indicated poorer sleep quality.

Physical activity. Physical activity was assessed using three items. The items assessed how many times in the last month participants were involved in physical activity on their own or with a team, that was either 1) high-intensity physical activity, 2) moderate-intensity physical activity, or 3) low-intensity physical activity. These categories are consistent with the Borg Rating of Perceived Exertion (CDC, 2015a) and target heart rate for monitoring physical activity (CDC, 2015b). The responses were based on a five-point Likert scale ranging from 1 (*every day*) to 5 (*not at all*). Higher scores indicated lower higher-intensity, moderate-intensity, and low-intensity physical activity, respectively.

Sport club involvement. Sport club involvement was assessed with one item examining how often participants participated in sports clubs since the start of the academic year. The responses were based on a five-point Likert scale ranging from 1 (*never*) to 6 (*several times a week*). Higher scores indicate higher involvement in sport clubs.

Plan of Analysis. An auto-regressive cross-lag analysis examining the associations among sleep quality, emotion regulation, physical activity (high, moderate, and low intensity), and sport club involvement across Times 2, 3, and 4 was conducted using MPlus version 7.4 (Muthén & Muthén, n.d.; see Figure 2-1). Significance level was set at $p = 0.05$.

Results

Preliminary Analysis

There were significant differences between males and females on sleep quality (Time 2 only), emotion regulation (Times 2, 3, and 4), moderate intensity physical activity (Times 2 and 3), high intensity physical activity (Times 2, 3, and 4), and sports club engagement (Times 2, 3, and 4), $ps < .035$, such that females reported lower sleep quality, emotion regulation, moderate and high intensity physical activity, and sports club engagement than did males.

Primary Analyses

Overall model fit for the autoregressive cross-lag path analysis was determined using the comparative fit index (CFI) and the root mean square error of approximation (RMSEA) indicators.(Hu & Bentler, 1999) The cut-off criteria recommended for a well-specified model are a CFI > .95 and a RMSEA < .06, simultaneously.(Hu & Bentler,

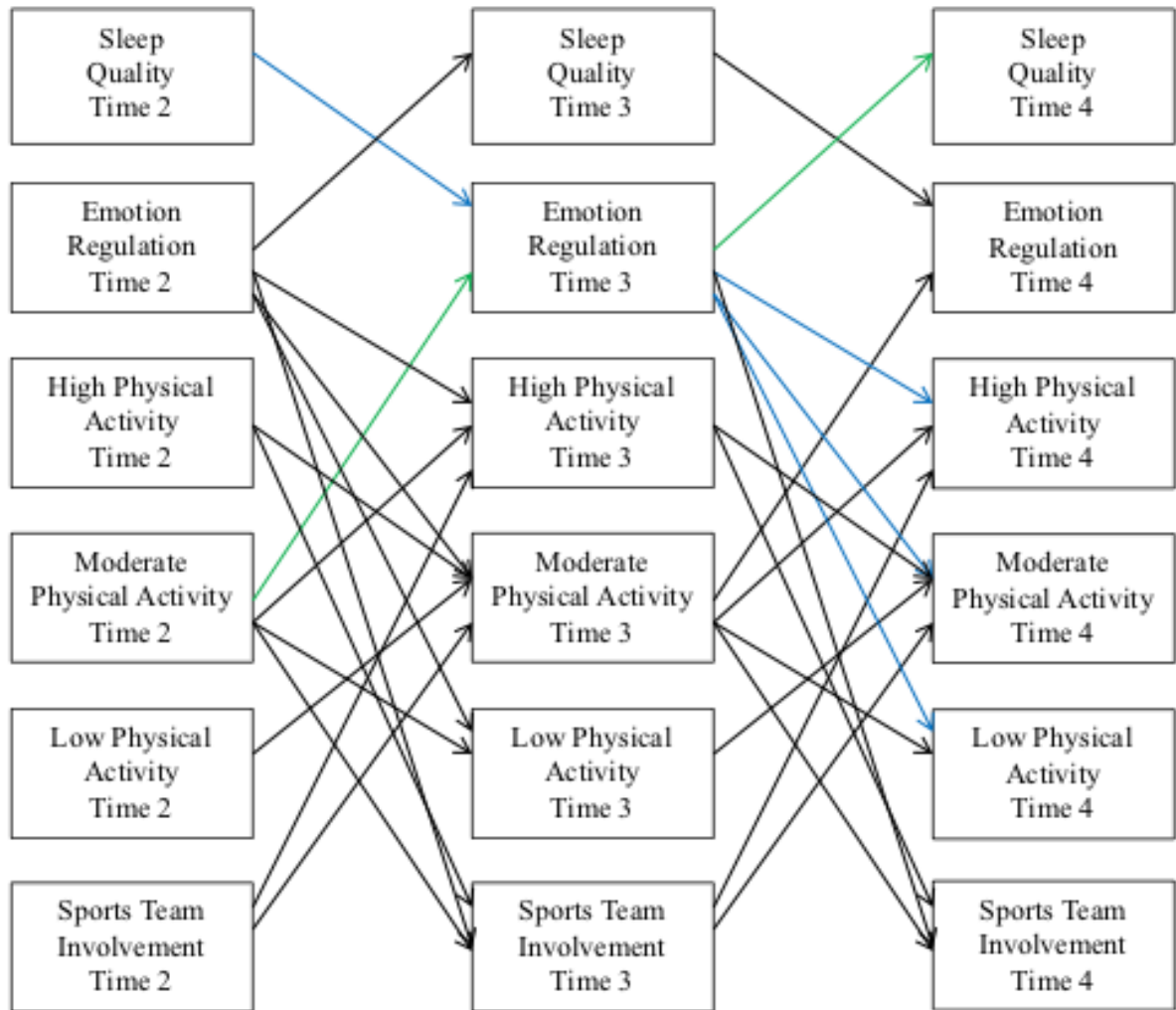


Figure 2-1. Significant cross-lag paths between study variables; the blue paths indicate the significant indirect effect

Table 2-1.

Descriptive statistics for study variables

Measure	Time 2	Time 3	Time 4
	<i>M (SD)</i>	<i>M (SD)</i>	<i>M (SD)</i>
Sleep Quality	2.462 (0.748)	2.377 (0.764)	2.323 (0.763)
Emotion Regulation	2.853 (0.759)	2.850 (0.766)	2.798 (0.773)
High Physical Activity	2.967 (1.229)	3.110 (1.301)	2.963 (1.276)
Moderate Physical Activity	2.789 (1.118)	2.808 (1.188)	2.736 (1.142)
Low Physical Activity	2.138 (1.193)	2.201 (1.182)	2.005 (1.091)
Sports Team Involvement	2.238 (1.790)	2.237 (1.801)	2.297 (1.805)
Covariates			
Gender	611 (73.88%) female		
Parent Education	3.71 (1.30)		
Born in Canada	703 (85.01%) born in Canada		

1999) across the three time periods, lag-1 cross-lag paths among all 6 variables, lag-1, and lag-2 autoregressive paths, and concurrent associations among all six 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 2, and paths estimated between the covariates and each variable at Times 3 and 4. 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.

The results of a Chi-Square Difference Test of Relative Fit indicated that the patterns of association among the variables were invariant across time, $\chi^2_{\text{diff}}(30) = 42.634$, $p > .05$. Thus, subsequent analyses were based on the model that was constrained over time. The constrained model fit was well-specified, $\chi^2(60) = 120.714$, $p < .001$, CFI = .990, RMSEA = .035, 90% CI [.026-.044], $p = .998$. Table 2-2 shows beta weights for all paths in the model for all six key study variables (model results are displayed in Figure 2-1; only paths from Times 2 to 3 are shown as the results are invariant across time).

Results revealed statistically significant indirect effects of Time 2 sleep quality on Time 4 high intensity physical activity, $\beta = .004$ [90% CI = .001 - .007], $SE = .002$, $p = .036$, moderate intensity physical activity, $\beta = .005$ [90% CI = .002 - .008], $SE = .002$, $p = .017$, and low intensity physical activity, $\beta = .007$ [90% CI = .003 - .012], $SE = .003$, $p = .006$, all through Time 3 emotion regulation. These results indicate that better sleep quality predicted greater emotion regulation over time, and in turn, greater emotion regulation predicted more frequent engagement in high, moderate, and low physical

Table 2-2.

Beta weights of study variables from Time 2 to Time 3.

Time 2		Time 3	<i>b</i>	β	<i>SE</i>	<i>P</i>
EmoReg2	→	Sleep3	.095	.098	.019	< .001
EmoReg2	→	HighPA3	.086	.054	.022	.013
EmoReg2	→	ModPA3	.098	.067	.022	.002
EmoReg2	→	LowPA3	.136	.094	.023	<.001
EmoReg2	→	Sports3	-.090	-.040	.020	.048
Sleep2	→	EmoReg3	.071	.073	.019	<.001
Sleep2	→	HighPA3	.021	.012	.021	.547
Sleep2	→	ModPA3	.041	.027	.022	.205
Sleep2	→	LowPA3	.012	.008	.023	.722
Sleep2	→	Sports3	-.004	-.002	.020	.922
HighPA2	→	Sleep3	-.018	-.030	.026	.246
HighPA2	→	EmoReg3	-.031	-.052	.027	.050
HighPA2	→	ModPA3	.107	.118	.030	< .001
HighPA2	→	LowPA3	-.016	-.018	.031	.577
HighPA2	→	Sports3	-.125	-.090	.028	.001
ModPA2	→	Sleep3	.017	.026	.026	.326
ModPA2	→	EmoReg3	.044	.066	.027	.014
ModPA2	→	HighPA3	.175	.161	.030	< .001
ModPA2	→	LowPA3	.083	.084	.032	.008
ModPA2	→	Sports3	-.111	-.073	.028	.008
LowPA2	→	Sleep3	-.010	-.016	.020	.431
LowPA2	→	EmoReg3	.004	.006	.021	.756
LowPA2	→	HighPA3	.026	.026	.023	.257
LowPA2	→	ModPA3	.074	.079	.023	.001
LowPA2	→	Sports3	.050	.035	.021	.099
Sports2	→	Sleep3	<.001	.000	.020	.983
Sports2	→	EmoReg3	.002	.004	.021	.829
Sports2	→	HighPA3	-.072	-.106	.023	< .001
Sports2	→	ModPA3	-.053	-.086	.023	<.001
Sports2	→	Low PA3	-.008	-.013	.024	.598

Note. b = unstandardized betas, β = standardized betas, SE = standard error for β , p =

significance value for β . EmoReg = emotion regulation, Sleep = sleep quality; HighPA = high physical activity; ModPA = moderate physical activity; LowPA = low physical activity; 2 = Time 2; 3 = Time 3. Only the results from Time 2 to Time 3 are shown as results were constrained across time. Covariate results can be obtained from the author.

activity over time. Of interest, the effects only were indirect, as there were no direct effects between sleep and physical activity over time, $ps > .200$. There also was an indirect effect from Time 2 moderate physical activity to Time 4 sleep quality via emotion regulation at Time 3, $\beta = .006$ [90% CI = .002 - .011], $SE = .003$, $p = .026$. See Figure 2-1 and Table 2-2 for other statistically significant results².

Discussion

The results of the current study indicate that there is support for a relationship between sleep and physical activity over time but *only through* emotion regulation. There was no evidence for direct links between physical activity and sleep over time, which may speak to the mixed results found previously in the literature. The present study provides the first longitudinal evidence for a link between sleep and physical activity in a young adult sample. Of note, only moderate levels of physical activity indirectly predicted lower sleep problems over time via emotion regulation, and sleep only indirectly predicted high, moderate, and low levels of physical activity over time via emotion regulation. Little research has examined how emotion regulation and emotions impacts on physical activity. However, in a recent review paper, Liao, Shonkoff and Dunton (2017) found that across a variety of studies, positive affect predicted more physical activity. Negative affect was found to be less strongly associated with physical activity (i.e., only one study found that negative affect was associated with lower physical activity; Liao et al., 2017). Although this is not a direct measure of emotion regulation,

² Note that although the results indicate that the path from Time 1 high intensity physical activity to Time 2 emotion regulation was non-significant, the beta is negative, which is the opposite of their bivariate correlation. This is most likely due to suppression, as the correlation between the physical activity measures were fairly high.

perhaps experiencing positive emotions – or regulating emotions to reduce negative affect – would be associated with physical activity. Future work incorporating both affect and emotion regulation could address this issue.

In addition, engaging in low and high intensity physical activity did not improve emotion regulation and subsequently sleep quality over time which has important implications for health recommendations. These results do, however, fall in line with recommendations of the Centre for Disease Control that indicate engaging in moderate and high intensity exercise will provide substantial health benefits (U.S. Department of Health and Human Services, 2008). It is surprising that the results for high intensity physical activity were not significant; perhaps, as indicated previously, the moderately high correlation between high and moderate physical activity suppressed its effects. At the same time, however, medium intensity physical activity was predicted by high and low physical activity. Perhaps low intensity physical activity (e.g., going for walks) is a starting point for the initiation of medium intensity physical activity, at least for young adults, which would subsequently promote better emotion regulation and sleep quality over time.

Although these results provide support and add to what was previously assumed about the relationship between physical activity and sleep, limitations of the current study must be addressed. The first limitation is that these data are based on self-report information. It would be beneficial to examine more objective measures of individuals' sleep quality (e.g., through actigraphy or EEG). However, self-report allows us to examine participants' *perception* about their sleep, which provides important information. A second limitation is that our sample was comprised only of undergraduate students. It

would be worthwhile to examine these questions with young adults who are not attending university as well as adolescents. Given that past longitudinal work has largely been conducted with older adults, it is important to examine this research questions in these other age groups. For example, adolescents (e.g., age 12-19) tend to have the highest proportion of individuals engaging in physical activity compared to other age groups (Statistics Canada, 2016) and thus, is important to examine how these associations may differ. It could be that similar patterns of results would be found as the findings of the current study parallel Holfeld and Ruthig's study(2014) conducted with older adults (although note that our results found an association from sleep to physical activity *only* through emotion regulation).

Overall, the results of the current study add support to previous research that has suggested a unidirectional relationship from sleep to physical activity, and sheds some light on research that has failed to find significant associations between these two factors.(Mitchell et al., 2016; Youngstedt, 2005) Although there were no significant *direct* effects between sleep and physical activity over time, these two factors were associated longitudinally *via* emotion regulation – that is, better sleep predicted better emotion regulation over time, which in turn predicted more frequent high, moderate, and low intensity physical activity over time. Further, moderate physical activity predicted fewer sleep problems over time via emotion regulation. Clearly, sleep and moderate physical activity play important roles in improving emotion regulation over time.

References

- Biddle, S. J. H., & Mutrie, N. (2008). *Psychology of physical activity: Determinants, well-being, and interventions* (2nd ed.). New York, NY: Routledge.
<https://doi.org/10.1097/00005768-200110000-00030>
- Brand, S., Gerber, M., Beck, J., Hatzinger, M., Pühse, U., & Holsboer-Trachsler, E. (2010a). Exercising, sleep-EEG patterns, and psychological functioning are related among adolescents. *The World Journal of Biological Psychiatry, 11*, 129–140.
<https://doi.org/10.3109/15622970903522501>
- Brand, S., Gerber, M., Beck, J., Hatzinger, M., Pühse, U., & Holsboer-Trachsler, E. (2010b). High exercise levels are related to favorable sleep patterns and psychological functioning in adolescents: A comparison of athletes and controls. *Journal of Adolescent Health, 46*, 133–141.
<https://doi.org/10.1016/j.jadohealth.2009.06.018>
- Brand, S., Kalak, N., Gerber, M., Clough, P. J., Lemola, S., Sadeghi Bahmani, D., ... Holsboer-Trachsler, E. (2016). During early to mid adolescence, moderate to vigorous physical activity is associated with restoring sleep, psychological functioning, mental toughness and male gender. *Journal of Sports Sciences*.
<https://doi.org/10.1080/02640414.2016.1167936>
- Brand, S., Kalak, N., Gerber, M., Kirov, R., Pühse, U., & Holsboer-Trachsler, E. (2014). High self-perceived exercise exertion before bedtime is associated with greater objectively assessed sleep efficiency. *Sleep Medicine, 15*, 1031–1036.
<https://doi.org/10.1016/j.sleep.2014.05.016>
- Bray, S. R., & Born, H. A. (2004). Transition to University and Vigorous Physical

Activity: Implications for Health and Psychological Well-Being. *Journal of American College Health*, 52(June), 181–188.

<https://doi.org/10.3200/JACH.52.4.181-188>

Buman, M. P., Phillips, B. A., Youngstedt, S. D., Kline, C. E., & Hirshkowitz, M. (2014).

Does nighttime exercise really disturb sleep? Results from the 2013 National Sleep Foundation Sleep in America Poll. *Sleep Medicine*, 15(7), 755–761.

<https://doi.org/10.1016/j.sleep.2014.01.008>

CDC. (2015a). Perceived Exertion (Borg Rating of Perceived Exertion Scale) | Physical Activity | CDC. Retrieved December 15, 2016, from

<https://www.cdc.gov/physicalactivity/basics/measuring/exertion.htm>

CDC. (2015b). Target Heart Rate and Estimated Maximum Heart Rate | Physical Activity | CDC. Retrieved December 15, 2016, from

<https://www.cdc.gov/physicalactivity/basics/measuring/hearttrate.htm>

Deliens, T., Deforche, B., De Bourdeaudhuij, I., & Clarys, P. (2015). Determinants of physical activity and sedentary behaviour in university students: a qualitative study using focus group discussions. *BMC Public Health*, 15, 201.

<https://doi.org/10.1186/s12889-015-1553-4>

Doane, L. D., Gress-Smith, J. L., & Breitenstein, R. S. (2015). Multi-method assessments of sleep over the transition to college and the associations with depression and anxiety symptoms. *Journal of Youth and Adolescence*, 44, 389–404.

<https://doi.org/10.1007/s10964-014-0150-7>

Dzierzewski, J. M., Buman, M. P., Giacobbi Jr, P. R., Roberts, B. L., Aiken-Morgan, A. T., Marsiske, M., & McCrae, C. S. (2014). Exercise and sleep in community-

- dwelling older adults: Evidence for a reciprocal relationship. *Journal of Sleep Research*, 23(1), 61–68. <https://doi.org/10.1111/jsr.12078>. Exercise
- Garaulet, M., Ortega, F. B., Ruiz, J. R., Rey-López, J. P., Béghin, L., Manios, Y., ... Moreno, L. A. (2011). Short sleep duration is associated with increased obesity markers in European adolescents: Effect of physical activity and dietary habits. The HELENA study. *International Journal of Obesity*, 35, 1308–1317. <https://doi.org/10.1038/ijo.2011.149>
- Gerber, M., Brand, S., Holsboer-Trachsler, E., & Pühse, U. (2010). Fitness and exercise as correlates of sleep complaints: Is it all in our minds? *Medicine & Science in Sports & Exercise*, 42(5), 893–901. <https://doi.org/10.1249/MSS.0b013e3181c0ea8c>
- Gratz, K. L., & Roemer, L. (2004). Multidimensional assessment of emotion regulation and dysregulation: Development, factor structure, and initial validation of the Difficulties in Emotion Regulation Scale. *Journal of Psychopathology and Behavioral Assessment*, 26(1), 41–54. <https://doi.org/10.1023/B:JOBA.0000007455.08539.94>
- Holfeld, B., & Ruthig, J. C. (2014). A longitudinal examination of sleep quality and physical activity in older adults. *Journal of Applied Gerontology*, 33(7), 791–807. <https://doi.org/10.1177/0733464812455097>
- Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, 6(1), 1–55. <https://doi.org/10.1080/10705519909540118>
- Kalak, N., Gerber, M., Kirov, R., Mikoteit, T., Yordanova, J., Pühse, U., ... Brand, S.

- (2012). Daily morning running for 3 weeks improved sleep and psychological functioning in healthy adolescents compared with controls. *Journal of Adolescent Health, 51*, 615–622. <https://doi.org/10.1016/j.jadohealth.2012.02.020>
- Liao, Y., Shonkoff, E. T., & Dunton, G. F. (2017). The acute relationships between affect, physical feeling states, and physical activity in daily life: A review of current evidence. In D. Jerkauc & R. Brand (Eds). *How do emotions and feelings regulate physical activity?* (pp. 91-97). Frontiers. <https://www.frontiersin.org/research-topics/3791/how-do-emotions-and-feelings-regulate-physical-activity>
- Little, T. D. (2013). *Longitudinal Structural Equation Modeling*. New York, NY: Guilford Press.
- Martin, B. J. (1981). Effect of sleep deprivation on tolerance of prolonged exercise. *European Journal of Applied Physiology, 47*, 345–354.
- Mitchell, J. A., Godbole, S., Moran, K., Murray, K., James, P., Laden, F., ... Glanz, K. (2016). *No Evidence of Reciprocal Associations between Daily Sleep and Physical Activity. Medicine and science in sports and exercise.*
<https://doi.org/10.1249/MSS.0000000000001000>
- Morin, C. M. (1993). *Insomnia: Psychological assessment and management*. New York, NY: Guilford Press.
- Muthén, L. K., & Muthén, B. O. (n.d.). *Mplus user's guide*. (M. & Muthén, Ed.) (6th ed.). Los Angeles, CA.
- Myllymäki, T., Kyröläinen, H., Savolainen, K., Hokka, L., Jakonen, R., Juuti, T., ... Rusko, H. (2011). Effects of vigorous late-night exercise on sleep quality and cardiac autonomic activity. *Journal of Sleep Research, 20*(1 PART II), 146–153.

<https://doi.org/10.1111/j.1365-2869.2010.00874.x>

- Myllymäki, T., Rusko, H., Syväoja, H., Juuti, T., Kinnunen, M. L., Kyröläinen, H., & George, K. P. (2012). Effects of exercise intensity and duration on nocturnal heart rate variability and sleep quality. *European Journal of Applied Physiology*, *112*(3), 801–809. <https://doi.org/10.1007/s00421-011-2034-9>
- O'Connor, P. J., Breus, M. J., & Youngstedt, S. D. (1998). Exercise-induced increase in core temperature does not disrupt a behavioral measure of sleep. *Physiology and Behavior*, *64*(3), 213–217. [https://doi.org/10.1016/S0031-9384\(98\)00049-3](https://doi.org/10.1016/S0031-9384(98)00049-3)
- Rampton, J. (2015). Do These 11 Things to Get the Best Sleep Ever. Retrieved December 15, 2016, from <http://www.success.com/article/do-these-11-things-to-get-the-best-sleep-ever>
- Ready, R. E., Marquez, D. X., & Akerstedt, A. (2009). Emotion in younger and older adults: Retrospective and prospective associations with sleep and physical activity. *Experimental Aging Research*, *35*(3), 348–368. <https://doi.org/10.1080/03610730902922184>
- Schafer, J. L., & Graham, J. W. (2002). Missing data - Our view of the state of the art. *Psychological Methods*, *7*(2), 147–177.
- Schmid, S. M., Hallschmid, M., Jauch-Chara, K., Wilms, B., Benedict, C., Lehnert, H., ... Schultes, B. (2009). Short-term sleep loss decreases physical activity under free-living conditions but does not increase food intake under time-deprived laboratory conditions in healthy men. *American Journal of Clinical Nutrition*, *90*(6), 1476–1482. <https://doi.org/10.3945/ajcn.2009.27984>
- Statistics Canada. (2016). *Table 105-0501 - Health indicator profile, annual estimates, by age group and sex, Canada, provinces, territories, health regions (2013*

boundaries) and peer groups, occasional, CANSIM (database). (accessed April 2, 2017)

- Tavernier, R., & Willoughby, T. (2014). A longitudinal examination of the bidirectional association between sleep problems and social ties at university: The mediating role of emotion regulation. *Journal of Youth and Adolescence*, 1–14.
<https://doi.org/10.1007/s10964-014-0107-x>
- Urner, M., Tornic, J., & Bloch, K. E. (2009). Sleep patterns in high school and university students: a longitudinal study. *Chronobiology International*, 26(6), 1222–1234.
<https://doi.org/10.3109/07420520903244600>
- Weaver, T. E., Laizner, A. M., Evans, L. K., Maislin, G., Chugh, D. K., Lyon, K., ... Dinges, D. F. (1997). An instrument to measure functional status outcomes for disorders of excessive sleepiness. *Sleep*, 20(10), 835–843.
- Youngstedt, S. D. (2005). Effects of exercise on sleep. *Clinics in Sports Medicine*, 24, 355–365. <https://doi.org/10.1016/j.csm.2004.12.003>
- Youngstedt, S. D., Kripke, D. F., & Elliott, J. A. (1999). Is sleep disturbed by vigorous late-night exercise? *Medicine and Science in Sports and Exercise*, 31(6), 864–9.
 Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/10378914>
- Youngstedt, S. D., Perlis, M. L., O'Brien, P. M., Palmer, C. R., Smith, M. T., Orff, H. J., & Kripke, D. F. (2003). No association of sleep with total daily physical activity in normal sleepers. *Physiology and Behavior*, 78, 395–401.
[https://doi.org/10.1016/S0031-9384\(03\)00004-0](https://doi.org/10.1016/S0031-9384(03)00004-0)

Chapter 3 – Psychosocial Adjustment Throughout University: A Longitudinal Investigation of the Roles of Sleep Quality and Emotion Dysregulation³

Emerging adulthood (i.e., late teens to the late 20s; Arnett & 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, Brown, & Soper, 2001) and emotion dysregulation (Srivastava, Tamir, McGonigal, John, & Gross, 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, Pickett, Deveson, & Kanona, 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).

³ The content of this chapter is based on the following published work: Semplonius, T., & Willoughby, T. (2018). Psychosocial adjustment throughout university: A longitudinal investigation of the roles of sleep quality and emotion dysregulation. *Journal of Youth and Adolescence*, doi: 10.1007/s10964-018-0826-5.

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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). Berking and Whitley (2014) indicate that emotion regulation encompasses a variety of ways by which individuals manage their emotional responses to various events or stimuli. Thus, emotion dysregulation in our study is defined as difficulty with regulating emotions in stressful situations.

Although a large volume of research has indicated that sleep problems and emotion dysregulation are associated (Cerolini, Balleisio, & Lombardo, 2015), researchers have tended to interpret these *concurrent* associations in only one of two ways. The first way is that sleep problems predict emotion dysregulation (Mauss, Troy, & LeBourgeois, 2013; Pickett, Barbaro, & Mello, 2015). 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, Gujar, Hu, Jolesz, & Walker, 2007). The second way is the opposite direction of effects; that is, that emotion dysregulation predicts sleep problems (Hoag, Tennen, Stevens, Coman, & Wu, 2016). One rationale for this association is that emotion dysregulation is thought to increase cognitive arousal, and cognitive arousal hinders sleep (Espie, Broomfield, Macmahon, Macphee, & Taylor, 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 six months, sleep predicted greater emotion dysregulation over time (O’Leary, Bylsma, & Rottenberg, 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 (2014) found support for a bidirectional relationship between emotion dysregulation and sleep problems (i.e., sleep problems predicted greater emotion dysregulation one year later, and emotion dysregulation predicted more sleep problems one year later); however, although emotion dysregulation was used as a moderator between sleep problems and social ties, the specific bidirectional relationship between sleep problems and emotion dysregulation was not tested. These results are consistent with both explanations for interpreting the association between the two factors (Gruber & 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, O’Malley, Bachman, & Schulenberg, 2006; Willoughby, Good, Adachi, Hamza, & Tavernier, 2013), and mental health problems, such as depression, are prevalent among university students (Center for Behavioral

Health Statistics and Quality, 2015; Pearson, Janz, & Ali, 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 & Willoughby, 2014a) and it can promote intrapersonal adjustment throughout the university years (Tavernier & 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, Hass, & Rowland, 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 & Oomen-Early, 2009; Conti, Adams, & Kisler, 2014; Lund, Reider, Whiting, & Prichard, 2010; Orzech, Salafsky, & Hamilton, 2011; Tempesta et al., 2010) and alcohol use (DeMartini & Fucito, 2014; Digdon & Landry, 2013; Kenney, Paves, Grimaldi, & Labrie, 2014; Singleton & Wolfson, 2009; Valerio, Kim, & Sexton-Radek, 2016). With regard to the relationship between sleep problems and alcohol use, the relationship is less than straightforward. Ebrahim, Shapiro, Williams, and Fenwick (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, Papineau, Rosenthal, and Roth (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, Ford, Storr, & Chan, 2004).

Emotion dysregulation also is associated with depressive symptoms (Nolen-Hoeksema & Aldao, 2011; Zawadzki, 2015) and alcohol use (Dragan, 2015; Dvorak et al., 2014; Fischer, Forthun, Pidcock, & Dowd, 2007; Kuvaas, Dvorak, Pearson, Lamis, & Sargent, 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, Tuschen-Caffier, Schnülle, Fischer, & Gross, 2010; Hopp, Troy, & Mauss, 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 & 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, Brower, Nigg, & Zucker, 2010). Other research has indicated that sleep quality and quantity did not predict alcohol use over time (Galambos, Vargas Lascano, Howard, & Maggs, 2013), but individuals who drank frequently during the week tended to go to bed later (Galambos, Dalton, & Maggs, 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, Rahkonen, Laaksonen, Lahelma, and Lallukka (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, Roberts, & Harris, 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, Wirtz, Svaldi, and Hofmann (2014) indicated that emotion dysregulation predicted more depressive symptoms five years later (although the

alternative direction of effects was not significant). In contrast, Berking, Orth, Wupperman, Meier, and Caspar (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, Bold, Sullivan, Armeli, & Tennen, 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 co-occur (Fairholme et al., 2013), it may be that each factor could be a mechanism through which 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 six months. We extended this work in the present study by examining whether sleep problems indirectly predict depressive symptoms via emotion dysregulation over a period of five 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 & 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 five 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 five 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 1,132 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”, $M = 3.71$. 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 (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 & 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 & 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. 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, Smith, Ybarra, Muntaner, & Tien, 2004; Radloff, 1977; Van Dam & 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 3-1. 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), $ps < .025$, 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, $ps < .001$, and reported fewer depressive symptoms at Time 4 than did students who were not born in Canada, $p < .040$.

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— see Figure 3-1. Overall model fit was determined using the comparative fit index (CFI) and the root mean square error of approximation (RMSEA) indicators (Hu & Bentler, 1999). The cut-off criteria

Table 3-1

Descriptive statistics for study variables.

Measures	Time 1 <i>M (SD)</i>	Time 2 <i>M (SD)</i>	Time 3 <i>M (SD)</i>	Time 4 <i>M (SD)</i>	Time 5 <i>M (SD)</i>
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%				

recommended for a well-specified model are a CFI > .95 and a RMSEA < .06, simultaneously (Hu & Bentler, 1999). Across the three 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.

The results of a Chi-Square Difference Test of Relative Fit indicated that the patterns of association among the variables were invariant across time, $\chi^2_{\text{diff}}(36) = 38.08$, $p = .375$. Thus, subsequent analyses were based on the model that was constrained over time, 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 3-2 shows beta weights for all paths in the model for all four key study variables (model results are displayed in Figure 3-1; 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, $\beta = .067$, $SE = .016$, $p < .001$, and emotion dysregulation

Table 3-2

Beta weights of study variables from Time 1 to Time 2.

			<i>b</i>	β	<i>SE</i>	<i>p</i>
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	.266
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

Note: *b* = unstandardized betas, β = standardized betas, *SE* = standard error for β , *p* = significance value for β . 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.

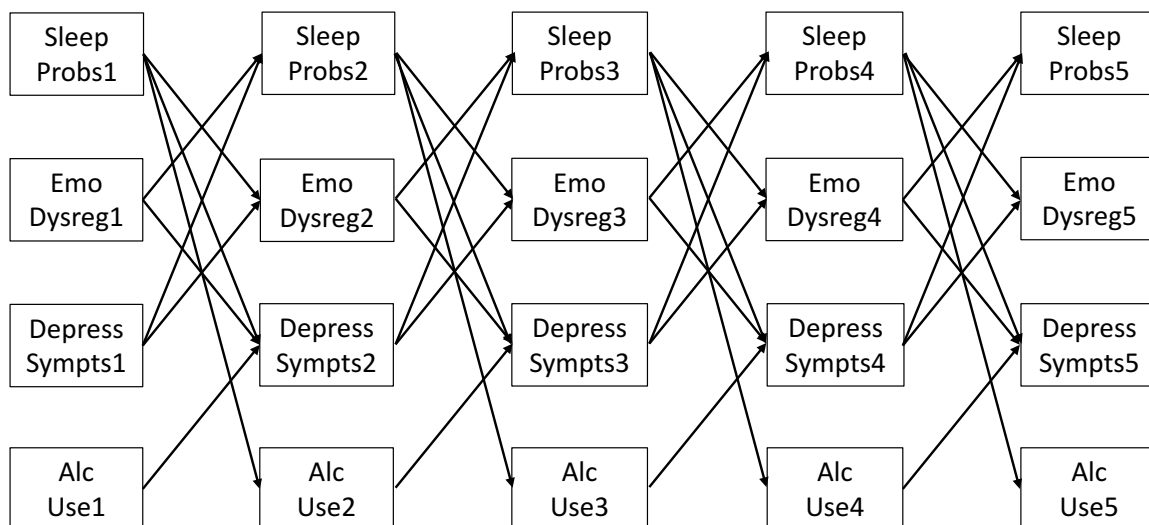


Figure 3-1. Significant cross-lag paths between study variables. Emo Dysreg = emotion dysregulation, Sleep Probs = sleep problems; Depress Sympts = depressive symptoms; Alc Use = drinking amount; 1 = Time 1; 2 = Time 2; 3 = Time 3; 4 = Time 4; 5 = Time 5.

predicted more sleep problems over time, controlling for previous sleep problems, $\beta = .042$, $SE = .016$, $p = .010$.

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, $\beta = .098$, $SE = .017$, $p < .001$, and depressive symptoms predicted more sleep problems over time, controlling for previous sleep problems, $\beta = .081$, $SE = .017$, $p < .001$. 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, $\beta = .087$, $SE = .018$, $p < .001$, and depressive symptoms predicted more emotion dysregulation over time, controlling for previous emotion dysregulation, $\beta = .088$, $SE = .018$, $p < .001$.

The results indicated two unidirectional associations as well. First, sleep problems predicted more alcohol use over time, controlling for previous alcohol use, $\beta = .026$, $SE = .013$, $p = .045$, and alcohol use predicted less depressive symptoms over time, controlling for previous depressive symptoms, $\beta = -.033$, $SE = .016$, $p = .040$. Of note, alcohol use did not predict sleep problems over time, $p = .410$, or emotion dysregulation over time, $p = .215$ (emotion dysregulation also did not predict alcohol use over time, $p = .326$); finally, depressive symptoms did not predict alcohol use over time, $p = .266$.

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 $\beta = .006$ [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, $\beta = .003$ [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, $\beta = .002$ [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, $\beta = .004$ [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, $\beta = .002$ [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, $\beta = .001$ [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 related (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., 2006; O'Malley & Johnston, 2002) – was recreational and social (Roehling & 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, Trivedi, Hoffmann, and Rush (1997) found that, in general, most sleep measures correlated well for both participants 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, Indursky, Kayumov, Sirota, & Melamed, 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 & Johnston, 2002). In addition, although clinical levels of mental health issues may not differ between these groups (Blanco & Okuda, 2008), a recent review paper indicated that depression was higher in college students than the general American population (Ibrahim, Kelly, Adams, & Glazebrook, 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 & 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 five 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*.

Overall, this work also highlights 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.

References

- Adachi, P., & Willoughby, T. (2015). Interpreting effect sizes when controlling for stability effects in longitudinal autoregressive models: Implications for psychological science. *European Journal of Developmental Psychology, 12*(1), 116–128. <https://doi.org/10.1080/17405629.2014.963549>
- Alvaro, P. K., Roberts, R. M., & Harris, J. K. (2013). A systematic review assessing bidirectionality between sleep disturbances, anxiety, and depression. *Sleep, 36*(7), 1059–1068. <https://doi.org/10.5665/sleep.2810>
- Armitage, R., Trivedi, M., Hoffmann, R., & Rush, A. J. (1997). Relationship between objective and subjective sleep measures in depressed patients and healthy controls. *Depression and Anxiety, 5*, 97–102.
- Armstrong, S., & Oomen-Early, J. (2009). Social connectedness, self-esteem, and depression symptomatology among collegiate athletes versus nonathletes. *Journal of American College Health, 57*(5), 521–526. <https://doi.org/10.3200/JACH.57.5.521-526>
- Arnett, J. J. (2000). Emerging adulthood: A theory of development from the late teens through the twenties. *American Psychologist, 55*(5), 469–480. <https://doi.org/10.1037/0003-066X.55.5.469>
- Arnett, J. J., & Fishel, E. (2013). *When will my grown-up kid grow up? Loving and understanding your emerging adult*. New York, NY: Workman Publishing Co., Inc.
- Bei, B., Milgrom, J., Ericksen, J., & Trinder, J. (2010). Subjective perception of sleep, but not its objective quality, is associated with immediate postpartum mood disturbances in healthy women. *Sleep, 33*(4), 531–538.

<https://doi.org/10.1093/sleep/33.4.531>

- Berking, M., Orth, U., Wupperman, P., Meier, L. L., & Caspar, F. (2008). Prospective effects of emotion-regulation skills on emotional adjustment. *Journal of Counseling Psychology, 55*(4), 485–494. <https://doi.org/10.1037/a0013589>
- Berking, M. & Whitley, B. (2014). Emotion regulation: Definition and relevance for mental health. In M. Berking and B. Whitley (eds.), *Affect regulation training: A practitioners' manual* (pp. 5-17). Springer Science+Business Media: New York, NY.
- Berking, M., Wirtz, C. M., Svaldi, J., & Hofmann, S. G. (2014). Emotion regulation predicts symptoms of depression over five years. *Behaviour Research and Therapy, 57*(1), 13–20. <https://doi.org/10.1016/j.brat.2014.03.003>
- Blanco, C., & Okuda, M. (2008). Mental health of college students and their non-college-attending peers. *Arch Gen Psychiatry, 65*(12), 1429–1437. <https://doi.org/10.1001/archpsyc.65.12.1429>.
- Buboltz, W. C., Brown, F., & Soper, B. (2001). Sleep habits and patterns of college students: A preliminary study. *Journal of American College Health, 50*(3), 131–135.
- Center for Behavioral Health Statistics and Quality. (2015). *Behavioral health trends in the United States: Results from the 2014 National Survey on Drug Use and Health*. Retrieved from <http://www.samhsa.gov/data/>
- Cerolini, S., Ballesio, A., & Lombardo, C. (2015). Insomnia and emotion regulation: Recent findings and suggestions for treatment. *Journal of Sleep Disorders and Management, 1*(1), 1–5.
- Conti, J. R., Adams, S. K., & Kisler, T. S. (2014). A pilot examination of self-esteem,

- depression, and sleep in college women. *NASPA Journal About Women in Higher Education*, 7(1), 47–72. <https://doi.org/10.1515/njawhe-2014-0004>
- Crum, R. M., Ford, D. E., Storr, C. L., & Chan, Y. F. (2004). Association of sleep disturbance with chronicity and remission of alcohol dependence: Data from a population-based prospective study. *Alcoholism: Clinical and Experimental Research*, 28(10), 1533–1540. <https://doi.org/10.1097/01.ALC.0000141915.56236.40>
- DeMartini, K. S., & Fucito, L. M. (2014). Variations in sleep characteristics and sleep-related impairment in at-risk college drinkers: A latent profile analysis. *Health Psychology*, 33(10), 1164–1173. <https://doi.org/10.1037/hea0000115>
- Digdon, N., & Landry, K. (2013). University students' motives for drinking alcohol are related to evening preference, poor sleep, and ways of coping with stress. *Biological Rhythm Research*, 44(1), 1–11. <https://doi.org/10.1080/09291016.2011.632235>
- Dragan, M. (2015). Difficulties in emotion regulation and problem drinking in young women: The mediating effect of metacognitions about alcohol use. *Addictive Behaviors*, 48, 30–35. <https://doi.org/10.1016/j.addbeh.2015.04.008>
- Dueck, A., Berger, C., Wunsch, K., Thome, J., Cohrs, S., Reis, O., & Haessler, F. (2017). The role of sleep problems and circadian clock genes in attention-deficit hyperactivity disorder and mood disorders during childhood and adolescence: an update. *Journal of Neural Transmission*, 124(s1), 127–138. <https://doi.org/10.1007/s00702-015-1455-8>
- Dvorak, R. D., Sargent, E. M., Kilwein, T. M., Stevenson, B. L., Kuvaas, N. J., & Williams, T. J. (2014). Alcohol use and alcohol-related consequences: Associations

- with emotion regulation difficulties. *The American Journal of Drug and Alcohol Abuse*, 40(2), 125–130. <https://doi.org/10.3109/00952990.2013.877920>
- Eaton, W. W., Smith, C., Ybarra, M., Muntaner, C., & Tien, A. (2004). Center for Epidemiologic Studies Depression Scale: Review and revision (CESD and CESD-R). In M. E. Maruish (Ed.), *The Use of Psychological Testing For Treatment Planning And Outcomes Assessment: Instruments For Adults* (3rd ed., pp. 363–377). Yahweh, NJ: Lawrence Erlbaum Associates Publishers.
- Ebrahim, I. O., Shapiro, C. M., Williams, A. J., & Fenwick, P. B. (2013). Alcohol and Sleep I: Effects on Normal Sleep. *Alcoholism: Clinical and Experimental Research*, 37(4), 539–549. <https://doi.org/10.1111/acer.12006>
- Ehring, T., Tuschen-Caffier, B., Schnülle, J., Fischer, S., & Gross, J. J. (2010). Emotion regulation and vulnerability to depression: spontaneous versus instructed use of emotion suppression and reappraisal. *Emotion (Washington, D.C.)*, 10(4), 563–572. <https://doi.org/10.1037/a0019010>
- Erikson, E. H. (1968). *Identity: Youth and Crisis*. New York, NY: Norton.
- Espie, C. A., Broomfield, N. M., Macmahon, K. M. A., Macphee, L. M., & Taylor, L. M. (2006). The attention-intention-effort pathway in the development of psychophysiologic insomnia: A theoretical review. *Sleep Medicine Reviews*, 10, 215–245. <https://doi.org/10.1016/j.smr.2006.03.002>
- Fairholme, C. P., Nosen, E. L., Nillni, Y. I., Schumacher, J. A., Tull, M. T., & Coffey, S. F. (2013). Sleep disturbance and emotion dysregulation as transdiagnostic processes in a comorbid sample. *Behaviour Research and Therapy*, 51(9), 540–546. <https://doi.org/10.1016/j.brat.2013.05.014>

- Fischer, J. L., Forthun, L. F., Pidcock, B. W., & Dowd, D. A. (2007). Parent relationships, emotion regulation, psychosocial maturity and college student alcohol use problems. *Journal of Youth and Adolescence*, *36*(7), 912–926.
<https://doi.org/10.1007/s10964-006-9126-6>
- Galambos, N. L., Dalton, A. L., & Maggs, J. L. (2009). Losing sleep over it: Daily variation in sleep quantity and quality in canadian students' first semester of university. *Journal of Research on Adolescence*, *19*(4), 741–761.
<https://doi.org/10.1111/j.1532-7795.2009.00618.x>
- Galambos, N. L., Vargas Lascano, D. I., Howard, A. L., & Maggs, J. L. (2013). Who sleeps best? Longitudinal patterns and covariates of change in sleep quantity, quality, and timing across four university years. *Behavioral Sleep Medicine*, *11*, 8–22. <https://doi.org/10.1080/15402002.2011.596234>
- Goldman-Mellor, S., Gregory, A. M., Caspi, A., Harrington, H., Parsons, M., Poulton, R., & Moffitt, T. E. (2014). Mental health antecedents of early midlife insomnia: Evidence from a four-decade longitudinal study. *Sleep*, *37*(11), 1767–1775.
<https://doi.org/10.5665/sleep.4168>
- Gratz, K. L., & Roemer, L. (2004). Multidimensional assessment of emotion regulation and dysregulation: Development, factor structure, and initial validation of the Difficulties in Emotion Regulation Scale. *Journal of Psychopathology and Behavioral Assessment*, *26*(1), 41–54.
<https://doi.org/10.1023/B:JOBA.0000007455.08539.94>
- Gross, R. T., & Borkovec, T. D. (1982). Effects of a cognitive intrusion manipulation on the sleep-onset latency of good sleepers. *Behavior Therapy*, *13*(1), 112–116.

[https://doi.org/10.1016/S0005-7894\(82\)80054-3](https://doi.org/10.1016/S0005-7894(82)80054-3)

- Gruber, R., & Cassoff, J. (2014). The interplay between sleep and emotion regulation: Conceptual framework empirical evidence and future directions. *Current Psychiatry Reports, 16*, 500. <https://doi.org/10.1007/s11920-014-0500-x>
- Haario, P., Rahkonen, O., Laaksonen, M., Lahelma, E., & Lallukka, T. (2013). Bidirectional associations between insomnia symptoms and unhealthy behaviours. *Journal of Sleep Research, 22*, 89–95. <https://doi.org/10.1111/j.1365-2869.2012.01043.x>
- Hoag, J. R., Tennen, H., Stevens, R. G., Coman, E., & Wu, H. (2016). Affect, emotion dysregulation, and sleep quality among low-income women. *Sleep Health, 2*, 283–288. <https://doi.org/10.1016/j.sleh.2016.08.006>
- Hopp, H., Troy, A. S., & Mauss, I. B. (2011). The unconscious pursuit of emotion regulation: Implications for psychological health. *Cognition and Emotion, 25*(3), 532–545. <https://doi.org/10.1080/02699931.2010.532606>
- Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal, 6*(1), 1–55. <https://doi.org/10.1080/10705519909540118>
- Hysenbegasi, A., Hass, S. L., & Rowland, C. R. (2005). The impact of depression on the academic productivity of university students. *Journal of Mental Health Policy and Economics, 8*(3), 145–151. <https://doi.org/http://dx.doi.org/10.4103/0019-5359.110850>
- Ibrahim, A. K., Kelly, S. J., Adams, C. E., & Glazebrook, C. (2013). A systematic review

- of studies of depression prevalence in university students. *Journal of Psychiatric Research*, 47(3), 391–400. <https://doi.org/10.1016/j.jpsychires.2012.11.015>
- Jansson-Fröjmark, M., & Lindblom, K. (2008). A bidirectional relationship between anxiety and depression, and insomnia? A prospective study in the general population. *Journal of Psychosomatic Research*, 64(4), 443–449. <https://doi.org/10.1016/j.jpsychores.2007.10.016>
- Johnston, L. D., O'Malley, P. M., Bachman, J. G., & Schulenberg, J. E. (2006). *Monitoring the Future: National Survey Results on Drug Use, 1975-2006 - Volume I, Secondary School Students. Monitoring the Future (Vol. I)*. Bethesda, MD. Retrieved from http://monitoringthefuture.org/pubs/monographs/vol1_2006.pdf
- Kenney, S. R., Paves, A. P., Grimaldi, E. M., & Labrie, J. W. (2014). Sleep Quality and Alcohol Risk in College of Drinking Motives. *Journal of American College Health*, 62(5), 301–308.
- Kuvaas, N. J., Dvorak, R. D., Pearson, M. R., Lamis, D. A., & Sargent, E. M. (2014). Self-regulation and alcohol use involvement: A latent class analysis. *Addictive Behaviors*, 39(1), 146–152. <https://doi.org/10.1016/j.addbeh.2013.09.020>
- Little, T. D. (2013). *Longitudinal Structural Equation Modeling*. New York, NY: Guilford Press.
- Lund, H. G., Reider, B. D., Whiting, A. B., & Prichard, J. R. (2010). Sleep patterns and predictors of disturbed sleep in a large population of college students. *Journal of Adolescent Health*, 46(2), 124–132. <https://doi.org/10.1016/j.jadohealth.2009.06.016>
- Markarian, S. A., Pickett, S. M., Deveson, D. F., & Kanona, B. B. (2013). A model of BIS/BAS sensitivity, emotion regulation difficulties, and depression, anxiety, and

- stress symptoms in relation to sleep quality. *Psychiatry Research*, 210(1), 281–286.
<https://doi.org/10.1016/j.psychres.2013.06.004>
- Mauss, I. B., Troy, A. S., & LeBourgeois, M. K. (2013). Poorer sleep quality is associated with lower emotion-regulation ability in a laboratory paradigm. *Cognition & Emotion*, 27(3), 1–10. <https://doi.org/10.1080/02699931.2012.727783>
- McRae, K., Gross, J. J., Weber, J., Robertson, E. R., Sokol-Hessner, P., Ray, R. D., ... Ochsner, K. N. (2012). The development of emotion regulation: an fMRI study of cognitive reappraisal in children, adolescents and young adults. *Social Cognitive and Affective Neuroscience*, 7(1), 11–22. <https://doi.org/10.1093/scan/nsr093>
- Morin, C. M. (1993). *Insomnia: Psychological assessment and management*. New York, NY: Guilford Press.
- Nezlek, J. B., & Kuppens, P. (2008). Regulating positive and negative emotions in daily life. *Journal of Personality*, 76(3), 561–580. <https://doi.org/10.1111/j.1467-6494.2008.00496.x>
- Nolen-Hoeksema, S., & Aldao, A. (2011). Gender and age differences in emotion regulation strategies and their relationship to depressive symptoms. *Personality and Individual Differences*, 51(6), 704–708. <https://doi.org/10.1016/j.paid.2011.06.012>
- O’Leary, K., Bylsma, L. M., & Rottenberg, J. (2016). Why might poor sleep quality lead to depression? A role for emotion regulation. *Cognition and Emotion*, 0(0), 1–9. <https://doi.org/10.1080/02699931.2016.1247035>
- O’Malley, P. M., & Johnston, L. D. (2002). Epidemiology of alcohol and other drug use among American college students. *Journal of Studies on Alcohol, Supplement*, (s14), 23–39. <https://doi.org/10.15288/jsas.2002.s14.23>

- Orzech, K. M., Salafsky, D. B., & Hamilton, L. A. (2011). The state of sleep among college students at a large public university. *Journal of American College Health : J of ACH*, 59(7), 612–9. <https://doi.org/10.1080/07448481.2010.520051>
- Pearson, C., Janz, T., & Ali, J. (2013). *Health at a glance: Mental and substance use disorders in Canada. Statistics Canada*. Retrieved from <http://www.statcan.gc.ca/pub/82-624-x/2013001/article/11855-eng.pdf>
- Pickett, S. M., Barbaro, N., & Mello, D. (2015). The relationship between subjective sleep disturbance, sleep quality, and emotion regulation difficulties in a sample of college students reporting trauma exposure. *Psychological Trauma: Theory, Research, Practice, and Policy*.
- Radloff, L. S. (1977). The CES-D Scale: A self-report depression scale for research in the general population. *Applied Psychological Measurement*, 1(3), 385–401.
- Roehling, P. V., & Goldman, M. S. (1987). Alcohol expectancies and their relationship to actual drinking experiences. *Psychology of Addictive Behaviors*, 1(2), 108–113. <https://doi.org/10.1037//0893-164X.1.2.108>
- Roehrs, T., Papineau, K., Rosenthal, L., & Roth, T. (1999). Ethanol as a hypnotic in insomniacs: Self administration and effects on sleep and mood. *Neuropsychopharmacology*, 20(3), 279–286. [https://doi.org/10.1016/S0893-133X\(98\)00068-2](https://doi.org/10.1016/S0893-133X(98)00068-2)
- Roehrs, T., & Roth, T. (2001). Sleep, sleepiness, and alcohol use. *Alcohol Research & Health*. <https://doi.org/doi: DOI: 10.1053/smr.2001.0162>
- Rosseel, Y. (2012). lavaan: An R package for structural equation modeling. *Journal of Statistical Software*, 48(2), 1–36. <https://doi.org/10.18637/jss.v048.i02>

- Rotenberg, V. S., Indursky, P., Kayumov, L., Sirota, P., & Melamed, Y. (2000). The relationship between subjective sleep estimation and objective sleep variables in depressed patients. *International Journal of Psychophysiology*, *37*, 291–297.
[https://doi.org/10.1016/S0167-8760\(00\)00110-0](https://doi.org/10.1016/S0167-8760(00)00110-0)
- Schafer, J. L., & Graham, J. W. (2002). Missing data - Our view of the state of the art. *Psychological Methods*, *7*(2), 147–177.
- Singleton, R. A., & Wolfson, A. R. (2009). Alcohol consumption, sleep, and academic performance among college students. *Journal of Studies on Alcohol and Drugs*, *70*(3), 355–363.
- Srivastava, S., Tamir, M., McGonigal, K. M., John, O. P., & Gross, J. J. (2009). The social costs of emotional suppression: A prospective study of the transition to college. *Journal of Personality and Social Psychology*, *96*(4), 883–897.
<https://doi.org/10.1037/a0014755>
- Tavernier, R., & Willoughby, T. (2014a). A longitudinal examination of the bidirectional association between sleep problems and social ties at university: The mediating role of emotion regulation. *Journal of Youth and Adolescence*, 1–14.
<https://doi.org/10.1007/s10964-014-0107-x>
- Tavernier, R., & Willoughby, T. (2014b). Bidirectional associations between sleep (quality and duration) and psychosocial functioning across the university years. *Developmental Psychology*, *50*(3), 674–82. <https://doi.org/10.1037/a0034258>
- Tempesta, D., Couyoumdjian, A., Curcio, G., Moroni, F., Marzano, C., De Gennaro, L., & Ferrara, M. (2010). Lack of sleep affects the evaluation of emotional stimuli. *Brain Research Bulletin*, *82*(1–2), 104–108.

<https://doi.org/10.1016/j.brainresbull.2010.01.014>

- Thompson, R. A. (1994). Emotion regulation: a theme in search of definition. *Monographs of the Society for Research in Child Development, 59*(2–3), 25–52.
Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/7984164>
- Valerio, T. D., Kim, M. J., & Sexton-Radek, K. (2016). Association of stress, general health, and alcohol use with poor sleep quality among U.S. college students. *American Journal of Health Education, 47*(1), 17–23.
<https://doi.org/10.1080/19325037.2015.1111173>
- Van Dam, N. T., & Earleywine, M. (2011). Validation of the Center for Epidemiologic Studies Depression Scale-Revised (CESD-R): Pragmatic depression assessment in the general population. *Psychiatry Research, 186*(1), 128–132.
<https://doi.org/10.1016/j.psychres.2010.08.018>
- Weiss, N. H., Bold, K. W., Sullivan, T. P., Armeli, S., & Tennen, H. (2016). Testing bidirectional associations among emotion regulation strategies and substance use: A daily diary study. *Addiction*. <https://doi.org/10.1111/add.13698>
- Willoughby, T., Good, M., Adachi, P. J. C., Hamza, C., & Tavernier, R. (2013). Examining the link between adolescent brain development and risk taking from a social-developmental perspective. *Brain and Cognition, 83*(3), 315–324.
<https://doi.org/10.1016/j.bandc.2013.09.008>
- Wong, M. M., Brower, K. J., Nigg, J. T., & Zucker, R. A. (2010). Childhood sleep problems, response inhibition, and alcohol and drug outcomes in adolescence and young adulthood. *Alcohol Clin Exp Res, 34*(6), 1033–1044.
<https://doi.org/10.1111/j.1530-0277.2010.01178.x>

Yoo, S. S., Gujar, N., Hu, P., Jolesz, F. a., & Walker, M. P. (2007). The human emotional brain without sleep - a prefrontal amygdala disconnect. *Current Biology*, *17*(20),

877–878. <https://doi.org/10.1016/j.cub.2007.08.007>

Zawadzki, M. J. (2015). Rumination is independently associated with poor psychological health: Comparing emotion regulation strategies. *Psychology & Health*, (March), 1–

18. <https://doi.org/10.1080/08870446.2015.1026904>

**Chapter 4 - A Person-Centred Analysis of Sleep Problems and Emotion
Dysregulation: Short- and Long-Term Links with Depressive Symptoms and
Alcohol Use⁴**

Young adulthood in Western culture often is a transitional period of identity exploration (e.g., career exploration, discovering the self; Erikson, 1968), instability (e.g., multiple residential moves), and feeling “in-between” (Arnett, 2000). These characteristics may be especially true for university students as they often leave home for the first time to attend university, experience multiple residential moves, and spend an extended period of time furthering their formal education and exploring career options. Although many students navigate this transitional period successfully, others experience adjustment difficulties throughout university, such as sleep problems (Buboltz, Brown, & Soper, 2001) and emotion dysregulation (Srivastava, Tamir, McGonigal, John, & Gross, 2009). Developmental theories, (e.g., Theory of Psychosocial Development; Erikson, 1968) suggest that difficulties during this transitional period can set the foundation for long-term problems (Masten, Faden, Zucker, & Spear, 2009). There is limited research, however, about whether difficulties in adjustment during the first year of university are long lasting (i.e., can lead to negative health outcomes over time). The purpose of the present study was to examine emotion dysregulation and sleep problems in first-year university students, and their short- and long-term associations with depressive symptoms and alcohol use.

⁴ The content of this chapter has been revised and resubmitted to *Journal of American College Health*

Sleep Problems and Emotion Dysregulation

Two adjustment difficulties common among first-year university students are sleep problems and difficulties with emotion regulation (Buboltz et al., 2001; Srivastava et al., 2009). In fact, findings from past research indicate that sleep problems often are associated with difficulties in emotion regulation (Gruber & Cassoff, 2014). For example, individuals with sleep problems display more difficulty in regulating emotions in general than individuals without sleep problems, and this is evident among both adults (Sandru & Voinescu, 2014) and university students with post-traumatic stress disorder (Pickett, Barbaro, & Mello, 2015). Similarly, Ready et al. (2009) found that young adults who indicate having sleep problems and/or who experience sleep duration that is too short (or long) tend to have increases in negative affect the next day. Individuals who report sleep problems also tend to use less cognitive reappraisal strategies when regulating their negative emotions (Mauss, Troy, & LeBourgeois, 2013). Furthermore, Sandru and Voinescu (2014) suggested that difficulties with emotion regulation can lead to sleep problems. For example, when individuals cannot regulate their emotions, they may become more aroused and, therefore, unable to sleep (Espie, Broomfield, Macmahon, Macphee, & Taylor, 2006). While these previous researchers predominately have used cross-sectional designs, Tavernier and Willoughby (2014a) found a longitudinal bidirectional association between emotion regulation and sleep problems, such that higher levels of emotion dysregulation predicted greater sleep problems over time, and higher levels of sleep problems predicted greater emotion dysregulation over time.

Both sleep problems and emotion dysregulation are considered to be transdiagnostic; that is, they tend to be common underlying factors of multiple health

problems (Fairholme et al., 2013). Aldao and Dixon-Gordon (2014) found that indicators of psychopathology such as symptoms of depression, anxiety, borderline personality disorder, anorexia nervosa and bulimia all were associated with maladaptive emotion regulation strategies (e.g., self-criticism, suppression, rumination). Fairholme et al. (2013) found (in a clinical, comorbid sample) when emotion dysregulation is controlled for, symptoms of insomnia still are associated with anxiety, depression, PTSD, and alcohol dependence (similar results were found for emotion dysregulation, controlling for symptoms of insomnia). These findings suggest that although sleep problems often are linked to difficulties with emotion regulation (and thus, may co-occur within the same individual), they also may be independent predictors of health outcomes, such that some individuals may display *only* sleep problems, others *only* emotion dysregulation, others *both* sleep problems and emotion dysregulation, and the remaining individuals *none* of these problems. However, using a variable-centered approach (as outlined above) does not allow for the examination of heterogeneity between participants. For example, Fairholme et al. found that both sleep and emotion regulation are associated with health outcomes *independent* of each other but also co-occurring within the same participants. Thus, a person-centred analysis would allow for the examination of distinct profiles of the relationship between sleep problems and emotion (dys)regulation *between* participants.

One method that can be used to test this hypothesis is a latent class analysis which specifically accounts for heterogeneity (i.e., individual differences) among individuals in the pattern of these behaviors (Bergman & Magnusson, 1997; Collins & Lanza, 2010); that is, is there a group of students who exhibit co-occurring sleep problems and emotion

dysregulation, a group of students who exhibit sleep problems only, a group of students who exhibit emotion dysregulation only, and a group that display neither sleep problems nor emotion dysregulation? An examination of this potential heterogeneity is critical for prevention/intervention efforts. Gaining information regarding how sleep and emotion dysregulation may be differentially associated between individuals and how these patterns of association are related to health indicators is important because it provides practitioners with valuable insight to potential long- and short-term outcomes for these individuals. This can enhance the ability of those in health care settings to reduce potential negative health outcomes. The first goal of this study, therefore, was to conduct a latent class analysis to examine the co-occurrence of sleep problems and emotion dysregulation.

Short and Long-Term Effects on Depressive Symptoms and Alcohol Use

The second goal of this study was to examine whether patterns of association between sleep problems and emotion dysregulation are differentially associated with disturbances in depressive symptoms and alcohol use both in the short-term (i.e., during the first year of university) and/or in the long-term. Depressive symptoms and alcohol use are of major concern in universities around the world. For example, the highest levels of binge drinking often occur among university students (Johnston, O'Malley, Bachman, & Schulenberg, 2006; Willoughby, 2013; Willoughby, Good, Adachi, Hamza, & Tavernier, 2013), and youth/young adults tend to report the highest rates of mental illness such as depression (Center for Behavioral Health Statistics and Quality, 2015; Pearson, Janz, & Ali, 2013). Importantly, researchers have found that both sleep problems and emotion dysregulation are related to depressive symptoms (Babson, Trainor, Feldner, &

Blumenthal, 2010; Baglioni et al., 2011; Markarian, Pickett, Deveson, & Kanona, 2013; Nolen-Hoeksema & Aldao, 2011; Tavernier & Willoughby, 2014b) and alcohol use (Dvorak et al., 2014; Galambos, Dalton, & Maggs, 2009; Kuvaas, Dvorak, Pearson, Lamis, & Sargent, 2014; Messman-Moore, Ward, Zerubavel, Chandley, & Barton, 2015; Wong, Brower, Nigg, & Zucker, 2010).

Sleep problems. Insomnia is thought to increase the risk of developing depression over time (Baglioni et al., 2011). Additionally, experimental work has demonstrated that sleep deprivation is associated with individuals rating neutral stimuli more negatively (in comparison to a control group; Tempesta et al., 2010), increases in negative mood (Tempesta et al., 2010), and increases in anxiety, depression, and distress (Babson et al., 2010). Short-term longitudinal work also has indicated that this relationship may be bidirectional (Tavernier & Willoughby, 2014b). Furthermore, sleep problems are associated with alcohol use. Individuals who consume alcohol throughout the day tend to have poor sleep quality and sleep less that night than individuals who do not consume alcohol throughout the day (Galambos et al., 2009). Additionally, developmental researchers have indicated that individuals who experience sleep problems in adolescence tend to have a higher risk of developing alcohol abuse in adulthood. For example, Wong et al. (2010) found that individuals who experienced overtiredness throughout childhood were more likely to have problems with alcohol use in adulthood.

Emotion dysregulation. Like sleep problems, emotion dysregulation is associated with depressive symptoms (Markarian et al., 2013). Hopp et al. (2011) found that participants who scored higher on the implicit valuing of emotion regulation displayed better psychological health (i.e., fewer depressive symptoms and better

wellbeing and social adjustment); however, this was seen only for participants who frequently used cognitive reappraisal strategies and not for those who did not frequently use these strategies. Additionally, in comparison to effective emotion regulation strategies (e.g., cognitive reappraisal), less effective emotion regulation strategies (e.g., suppression) were found to be associated with increases in depressive symptoms (Nolen-Hoeksema & Aldao, 2011), less positive affect, lower levels of self-esteem, and poor psychological adjustment (Nezlek & Kuppens, 2008). Emotion dysregulation also is associated with alcohol use (Messman-Moore et al., 2015). Dvorak et al.(2014) found that when individuals were unable to accept or control their emotional responses, more problematic outcomes from alcohol use were likely. Similarly, Kuvass et al. (2014) found that problematic drinking was related to difficulties regulating emotions. Overall, while both sleep problems and emotion dysregulation have been shown to be related to depressive symptoms and alcohol use, limited longitudinal research with university students has been conducted looking at these associations in the short and long-term.

The Current Study

The purpose of the current study was twofold. The first goal was to conduct a latent class analysis to examine individual differences in the pattern of self-reported sleep problems and emotion dysregulation among first-year university students. The second goal was to examine whether this co-occurrence was related to both short- and long-term depressive symptoms and alcohol use.

Methods

Participants

Participants in the current study were 1,132 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, $SD = 11.16$ months, range 17.8–25.5 years). SES data indicated that mean levels of education for mothers and fathers of these students fell between “*some college, university, or apprenticeship program*” and “*completed a college/apprenticeship and/or technical diploma*” ($M = 3.71$, $SD = 1.27$, range 1-6). The sample consisted 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. Participants' ID numbers were linked with names only for re-contacting purposes; these links were never included with their survey responses and were kept in a locked file separate from the survey files. Participants were given the option to select either course credit or monetary compensation (\$10) at Time 1, and were given \$50 for compensation at Time 5. Depressive symptoms and alcohol use were assessed again in this wave. The University Ethics Board approved the study, and all participants provided informed consent prior to participation.

Missing Data Analysis

Missing data occurred within each assessment time point because some students did not answer every question (average missing data at Time 1 and Time 5 were 5.80%

and 3.02% respectively) and because some students did not complete both waves of the survey. The number of participants at Time 1 was 1132 and the number of participants at Time 5 was 746 (note that missing data were imputed – see below). The participant retention rate was 65.9%.

The multivariate results of a MANOVA examining whether participants who participated in the study at both time periods differed from participants who completed only the first time period on Time 1 study variables, indicated there was a significant effect, Pillai's trace = .04, $F(17, 949) = 2.23$, $p = .003$, $\eta^2 = .04$. Specifically, participants who completed both time periods were more likely than participants who completed the survey only at Time 1 to be female, $F(1,965) = 9.05$, $p = .003$, $\eta^2 = .01$, and less likely to report drinking alcohol, $F(1,965) = 17.73$, $p < .001$, $\eta^2 = .02$. Missing data were imputed using the EM (expectation-maximization) algorithm with all study measures included in the imputation process (Little, 2013). Methodological research has demonstrated that this method of dealing with missing data is preferable to more common methods such as pairwise deletion, list-wise deletion, or mean substitution (Schafer & Graham, 2002).

Measures.

The current study included measures of demographics, emotion dysregulation and sleep problems at Time 1, and depressive symptoms and alcohol use at Times 1 and 5 (see Table 4-1 for descriptive statistics). Demographic variables included: sex (1 = *male* or 2 = *female*), parental education (one item per parent, $r = 0.43$, $p < .001$, 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*). Demographic variables were used as covariates in all analyses.

Sleep problems. Sleep problems were assessed at Time 1 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 interfered 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 all variables were on the same scale. Cronbach's alpha for the sleep items was .77. Higher scores indicated more sleep problems.

Emotion dysregulation. Emotion dysregulation was assessed at Time 1 with six items from the Difficulties in Emotion Regulation Scale (e.g., "When I'm upset or stressed, I have difficulty concentrating"; Gratz & Roemer, 2004) The responses were based on a five-point Likert scale ranging from 1 (*almost never*) to 5 (*almost always*). Cronbach's alpha was .73. Higher scores indicated more emotion dysregulation.

Depressive symptoms. Depressive symptoms were measured using The Center for Epidemiological Depression –Revised Scale (e.g., "I thought my life had been a failure"; Eaton, Smith, Ybarra, Muntaner, & Tien, 2004; Radloff, 1977; Van Dam & Earleywine, 2011). 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. The scale has good reliability. 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

Table 4-1

Descriptive statistics for study variables.

Measure	Time 1 <i>M (SD)</i>	Time 5 <i>M (SD)</i>
Sleep Problems		
Problems falling sleeping	2.55 (1.13)	
Problems staying asleep	1.89 (1.07)	
Wake up too early	2.13 (1.22)	
Problems staying awake	2.02 (1.00)	
Sleep pattern satisfaction	3.11 (1.02)	
Sleep interference	2.70 (1.06)	
Emotion Dysregulation		
Feel bad about oneself	2.49 (1.22)	
Difficulty concentrating	3.41 (1.14)	
Can't get things done	3.05 (1.10)	
Can't feel better	2.39 (1.10)	
Can't think about anything	3.41 (1.18)	
All I can do is wallow	1.94 (0.97)	
Depressive symptoms	19.88 (10.75)	17.63 (9.88)
Alcohol Use	3.84 (1.36)	3.47 (1.01)
Covariates		
Sex	70.5% female	
Parent education	3.71 (1.27)	
Born in Canada	84.9%	

indicated greater depressive symptoms. Cronbach's alphas at Time 1 and Time 5 were .91 and .93 respectively.

Alcohol use: Alcohol use was assessed by asking participants how many drinks they have, on average, when they are drinking alcohol. Responses options were as follows: 1 (*less than 1 drink*), 2 (*1 drink*), 3 (*2-3 drinks*), 4 (*4-6 drinks*), 5 (*7-10 drinks*) and 6 (*over 10 drinks*). Higher scores indicate more alcohol use.

Results

Statistical analyses were carried out using MPlus 7 (Muthén & Muthén, n.d.) and SPSS version 23. All variables displayed acceptable levels of skewness and kurtosis. To identify individual differences in the pattern of emotion dysregulation and sleep problems, a latent class analysis (LCA; Nagin, 2005) was conducted. The six sleep problem items and the six emotion dysregulation items from Time 1 were entered as class indicators into the LCA. Sex, whether participants were born in Canada or not, and parental education also were included as covariates. In order to determine the number of groups best represented by the data, several criteria were considered: 1) interpretability of the classes, 2) Bayesian information criterion (BIC), such that smaller values of BIC indicate a better fit model, 3) significance of the Lo-Mendell-Rubin Adjusted Likelihood Ratio Test (LMR-LRT) and/or the Bootstrap Likelihood Ratio Test (BLRT), which compare a particular model to a model with one fewer classes (i.e., a significant p value indicates that the estimated model provides a better fit to the data than the model with fewer classes), and 4) average latent class posterior probabilities close to 1.00 (Nylund, Asparouhov, & Muthén, 2007). Entropy (an index of confidence that individuals belong to the correct class and that adequate separation between latent classes exists) also was

examined; scores of .80 and higher are good but there is no set cut-off criterion for entropy (Jung & Wickrama, 2008).

Fit indices for the LCA indicated that the four-class solution was considered the optimal model (see Table 4-2). The LMR-LRT became non-significant at five classes, indicating that adding the fifth class did not significantly improve the model. Furthermore, the entropy value for four classes was .85 (whereas it was .81 for five classes), and the average latent classes posterior probabilities ranged from .86 to .94, indicating that a high proportion of participants were correctly classified. There also was good distinction among the four classes. Finally, the drop in the BIC from four to five classes was much smaller than the drop from three to four classes, again suggesting that the four-class solution best fit the data.

Table 4-2

Latent class analysis (LCA) fit indices.

Number of Classes	BIC	Entropy	LMR-LRT	Loglikelihood <i>p</i> -value
2 Classes	36791.68	.813	-19214.80	< .001
3 Classes	36094.15	.837	-18256.24	.003
4 Classes	35786.24	.848	-17852.13	.031
5 Classes	35635.96	.813	-17641.84	.399

The four groups were: 1) Low Co-Occurrence (low sleep problems/low emotion dysregulation; 29.1% of the sample), 2) Sleep Problems Only (moderate sleep

problems/low-moderate emotion dysregulation; 11.4% of the sample), 3) Emotion Dysregulation Only (low-moderate sleep problems/moderate-high emotion dysregulation; 42.4% of the sample), and 4) High Co-occurrence (high sleep problems/high emotion dysregulation; 17.0% of the sample). To ensure groups were classified appropriately, a MANOVA with Bonferroni correction was conducted using group membership as the independent variable and each of the class indicators (i.e., sleep problem and emotion dysregulation items) as dependent variables. Results supported our class characterizations and group differences are presented in Table 4-3. Guidelines for clinical cut-off scores (summed scores that were adjusted for the number of scale items in the current study) also supported our classes (Bastien, Vallieres, & Morin, 2001; Gratz & Tull, 2010).

According to the cutoffs from Bastien et al. (2001), the High Co-Occurrence group had levels of insomnia scores in line with “clinical insomnia (moderate severity)”, $M = 14.81$. The Sleep Problems only group had scores in line with “subthreshold insomnia”, $M = 11.86$, whereas the Emotion Dysregulation Only fell between “subthreshold insomnia” and “no clinically significant insomnia”, $M = 7.38$. The Low Co-Occurrence group was consistent with “no clinically significant insomnia”, $M = 4.91$. The only groups that reported emotion dysregulation scores consistent with clinical populations were the Emotion Dysregulation Only and High Co-Occurrence groups ($M = 18.24$ and 21.81 , respectively; emotion dysregulation scores for Sleep Problems Only and Low Co-Occurrence were consistent with the general population; means were 13.94 and 12.45 respectively).

Table 4-3

Group means and standard deviations of items used in the LCA.

	Group 1 Low Co- Occurrence	Group 2 Sleep Problems Only	Group 3 Emotion Dysregulation Only	Group 4 High Co- Occurrence
<i>Measures</i>	<i>M (SD)</i>	<i>M (SD)</i>	<i>M (SD)</i>	<i>M (SD)</i>
Problems falling asleep	1.81 _a (0.76)	3.47 _c (0.82)	2.29 _b (0.90)	3.93 _d (0.87)
Problems staying asleep	1.24 _a (0.46)	2.84 _c (1.04)	1.56 _b (0.71)	3.22 _d (1.10)
Wake up too early	1.80 _a (1.03)	2.66 _b (1.30)	1.94 _a (1.11)	2.83 _b (1.43)
Problems staying awake	1.54 _a (0.74)	2.15 _b (0.98)	1.97 _b (0.89)	2.90 _c (1.19)
Sleep pattern satisfaction	2.47 _a (0.85)	3.85 _c (0.68)	2.92 _b (0.85)	4.25 _d (0.72)
Sleep interference	2.04 _a (0.88)	2.89 _b (0.93)	2.70 _b (0.96)	3.68 _c (0.97)
Feel bad about oneself	1.81 _a (0.87)	2.25 _b (1.09)	2.52 _b (1.14)	3.71 _c (1.16)
Difficulty concentrating	2.20 _a (0.62)	2.39 _a (0.70)	4.09 _b (0.63)	4.48 _c (0.59)
Can't get things done	2.64 _a (1.11)	2.91 _{a, b} (1.10)	3.19 _{b, c} (1.04)	3.42 _c (1.13)
Can't feel better	2.12 _a (1.11)	2.38 _a (1.15)	2.31 _a (1.02)	2.97 _b (1.08)
Can't think about anything	2.26 _a (0.83)	2.41 _a (0.88)	4.06 _b (0.69)	4.46 _c (0.65)
All I can do is wallow	1.40 _a (0.65)	1.60 _a (0.74)	2.06 _b (0.92)	2.78 _c (1.12)

Note. Means within the same row that share subscripts are not significantly different.

Individuals were assigned to their highest probability class, but it is important to note that there is error involved with assigning individuals into groups based solely on posterior probabilities

The second purpose of this study was to assess whether these distinct groups of individuals appeared to be at differential risk for short- and long-term problems in depressive symptoms and alcohol use. To address this question, we examined group differences on depressive symptoms and alcohol use at Time 1 and Time 5 (4 years later). Means and standard deviations are shown in Table 4-4 and these results also are displayed in Figure 4-1.

A repeated-measures ANCOVA indicated a significant multivariate effect for a three-way interaction between time (Time1, Time5), class (Group 1, 2, 3, 4) and type (depressive symptoms, alcohol use), Pillai's trace = .08, $F(3, 1068) = 31.55, p < .001, \eta^2 = .08$. The three-way interaction was followed up with two MANCOVAs. For short-term results, a MANCOVA at Time 1 indicated that the multivariate effect of class was significant, Pillai's Trace = .30, $F(6,2136) = 68.93, p < .001, \eta^2 = .15$, with group differences on depressive symptoms, $F(3, 1068) = 148.72, p < .001, \eta^2 = .30$, and alcohol use, $F(3, 1068) = 2.70, p = .04, \eta^2 = .01$ (see Table 4-4). For depressive symptoms, Games-Howell pairwise comparisons indicated that the Low Co-Occurrence Group reported fewer symptoms than all other groups whereas the High Co-Occurrence Group

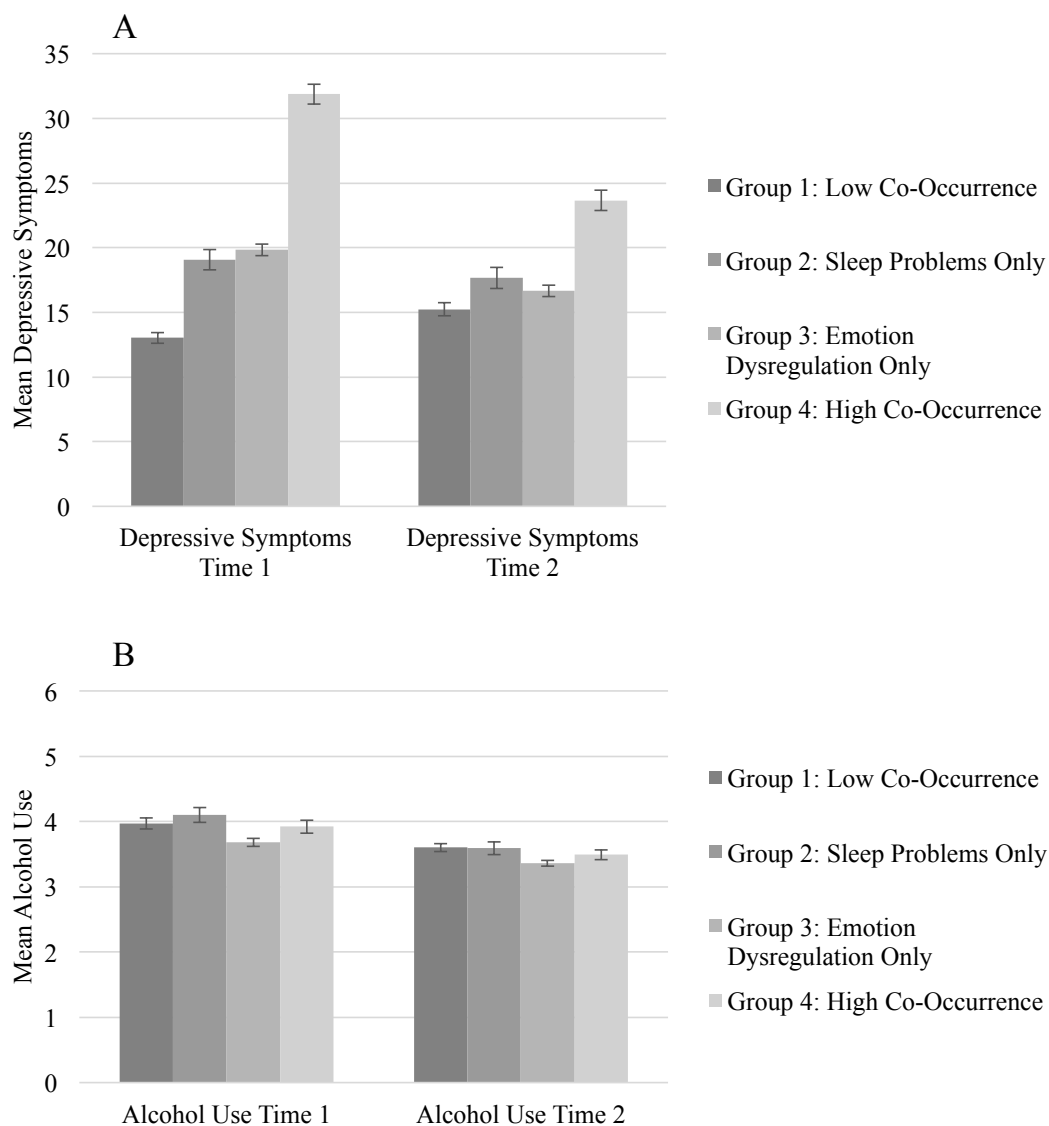


Figure 4-1. This figure displays the results of the 3-way interaction. For ease of presentation, Part A outlines the group results for depressive symptoms at Times 1 and 2, and Part B outlines the group results for alcohol use at Times 1 and 2.

Table 4-4

Means and standard deviations of depressive symptoms and alcohol use as a function of class at Time 1 and Time 5.

	Group 1 Low Co- Occurrence	Group 2 Sleep Problems Only	Group 3 Emotion Dysregulation Only	Group 4 High Co- Occurrence
<i>Measures</i>	<i>M (SD)</i>	<i>M (SD)</i>	<i>M (SD)</i>	<i>M (SD)</i>
Depressive Symptoms Time 1	13.02 _a (7.31)	19.07 _b (8.70)	19.83 _b (9.53)	31.87 _c (10.37)
Depressive Symptoms Time 5	15.24 _a (8.96)	17.66 _a (9.04)	16.66 _a (9.39)	23.66 _b (10.62)
Alcohol Use Time 1	3.97 _{a,b} (1.50)	4.10 _b (1.26)	3.68 _a (1.31)	3.92 _{a,b} (1.34)
Alcohol Use Time 5	3.60 _a (1.07)	3.59 _a (1.08)	3.36 _a (0.94)	3.49 _a (1.01)

note. Means within the same row that share subscripts are not significantly different.

Individuals were assigned to their highest probability class, but it is important to note that there is error involved with assigning individuals into groups based solely on posterior probabilities.

reported more symptoms than all other groups. The Sleep Problems Only and the Emotion Dysregulation Only Groups did not differ significantly from each other. For alcohol use, Hochberg's GT2 pairwise comparisons indicated that the Sleep Problems Only Group reported higher number of drinks per drinking session than the Emotion Dysregulation Only Group. There were no other significant differences.

Results of a MANCOVA at Time 5 (four years after Time 1) indicated that the effect of class was significant, Wilk's Lamda = .91, $F(6,2134) = 18.23$, $p < .001$, $\eta^2 = .05$, with group differences on self-reported depressive symptoms, $F(3, 1068) = 35.94$, $p < .001$, $\eta^2 = .09$, but not on self-reported alcohol use, $p = .36$, (see Table 4-4). In regard to depressive symptoms, Games-Howell pairwise comparisons indicated that the High Co-Occurrence group displayed more depressive symptoms at Time 2 than all other groups.

Discussion

The current study is among the first in which heterogeneity in the long-term effect of adjustment difficulties (i.e., sleep problems and emotion dysregulation) in first-year university students was examined. Overall, our results indicated that the co-occurrence of self-reported sleep problems and emotion dysregulation was evident in this sample of undergraduate students. Importantly, the High Co-Occurrence Group displayed depressive symptoms that were above or at clinical cut-offs at Time 1 ($M = 31.87$, $SD = 10.37$) and Time 5 ($M = 23.66$, $SD = 10.62$; Vilagut, Forero, Barbaglia, & Alonso, 2016). In addition, our results indicate that the co-occurrence of sleep problems and emotion dysregulation was related to depressive symptoms both in the short- and long-term. That is, individuals with high co-occurrence of sleep problems and emotion dysregulation experienced the most depressive symptoms among their peers at Time 1 and 4 years later,

indicating that individuals with two highly co-occurring problems are at risk for long-term negative health outcomes, and are a target group that would benefit from programs that specifically address adjustment difficulties in first-year university students. This finding indicates that it is critical for researchers to pay attention to long-term effects (Bromet, 2016).

In contrast, the group differences about alcohol use (i.e., number of drinks) were less robust. The minimal differences at Time 1 and the lack of group differences at Time 2 may be due to the fact that levels of drinking for many students elevate throughout the person's years at the university (and are higher than individuals aged 25 years and older; Thomas, 2012) Indeed, in the current study, self-reported alcohol use at Time 1 was around 4-6 drinks per drinking session (i.e., at binge drinking levels). Even at Time 5, the group means were between 2-3 drinks and 4-6 drinks per drinking session. Thus, drinking habits across student years at the university tended to remain relatively stable, regardless of what group participants were in, which may be why no group differences on alcohol use were found. However, a second potential reason that group differences may not have been present may be because individuals drink for different reasons. For example, past researchers have indicated that individuals engage in higher levels of alcohol use during celebrations, to reduce inhibition like shyness, and to forget things they may worry about (Kairouz, Gliksman, Demers, & Adlaf, 2002). It may be that the groups in the current study differed in their motives for drinking. Individuals in the high co-occurring group (i.e., high levels of sleep problems and emotion dysregulation) – who also display high levels of depressive symptoms – could be using alcohol as a coping mechanism (e.g., using alcohol as self-medication). In contrast, perhaps those in the low co-occurring

group (i.e., low levels of sleep problems and emotion dysregulation) use alcohol in a less problematic manner (e.g., when socializing with friends). As we did not assess motives for drinking in the present study, future research should examine whether these groups do differ on aspects such as problematic coping behaviours and social behaviours.

A major strength of our study is that we explicitly examined individual differences using a person-centered approach, rather than a variable-centered approach. Previous researchers have investigated trajectories of wellbeing in young adulthood; for instance, Galambos et al. (2006) found that, on average, wellbeing (measured by depression, self-esteem, and anger) improved from 18 to 25 years of age and that enrolling in university and leaving home did not predict greater change in wellbeing over time in comparison to youth who did not attend a university. These results, however, were based on variable-centered analyses, specifically examining average change across all university students versus average change across non-university students. While these findings provide important information about the association between university attendance and adjustment, using a variable-centered analysis masks the heterogeneity of participant responses and profiles, and mitigates the potential to identify at-risk students. Our person-centered analysis adds an important dimension to our knowledge of how distinct profiles of first-year university student problems are related in the short- and long-term to adjustment problems.

Although our results display findings that should be of interest to those in college settings, it must be noted that the results of the current study are based on a sample of Canadian university students which may differ from a sample of university students in the United States. Similarities among university students in the two countries, however, are

clear (see National College Health Assessment 2016 results, carried out with both Canadian and US students; American College Health Association, n.d.) With regard to alcohol use, binge drinking occurs at high levels with both American university students (Johnston et al., 2006) and Canadian university students (Willoughby, 2013; Willoughby et al., 2013). Indeed, the World Health Organization has indicated that the highest level of alcohol use tends to be found in the Americas – including Canada and the United States – and Europe (and this is the case for youth [age 15-19] alcohol consumption as well; *Global status report on alcohol and health, 2014*, 2014) Depressive symptoms and sleep problems also are fairly prevalent in youth/young adults in both the United States (Center for Behavioral Health Statistics and Quality, 2015) and Canada (Pearson et al., 2013). Emotion dysregulation also is unlikely to be different among students in the two countries.

The results of the current study can be applied to the work carried out by both Canadian and American university health practitioners. For example, our results demonstrate that in the short term (i.e., our concurrent results), depressive symptoms were moderately high for individuals who displayed either sleep problems *or* emotion dysregulation; however, these findings did not persist over the long term. Perhaps these individuals experienced a stressful transition in their first year of being in the university, thus they displayed moderate levels of depressive symptoms during that time; it also could be that these individuals utilized new coping mechanisms to deal with adjustments throughout this period of time. However, over the long term, these symptoms appeared to diminish and were at the same level of those in the low co-occurrence group. One way university health practitioners may be able to aid students would be to address methods of

improving either sleep quality or difficulties with regulating emotions; alternatively, if it is simply adjustment to university in general, one potential strategy could be to help find or develop a variety of coping strategies to deal with adjustment difficulties. In contrast, individuals with high co-occurrence displayed elevated levels of depressive symptoms in both the short- and long-term. Perhaps one way of identifying these individuals is to have health practitioners that are already in contact with students also assess – at a subjective level – whether the students are experiencing sleep difficulties and/or difficulties regulating emotions that they experience. These students in particular would benefit from some form of intervention or assistance – specifically targeting both sleep problems and emotion dysregulation – starting in first year university.

Limitations

The strengths of the current study also have to be balanced with its limitations. First, as the sample consisted only of university students who tend to be frequent drinkers of alcohol, variability in drinking behaviours may have been small (or group differences in reasons for consuming alcohol may have differed) leading to an inability to find group differences. The findings may differ in populations where alcohol use is not as high as it is in young adulthood (e.g., for individuals over the age of 25; Thomas, 2012). Second, these findings do not apply to the general population as they were based on a single university sample. An advantage of using one university sample, however, is that we were able to develop a strong relationship with the participants, and thus, retention was high over time. In addition, the pattern of findings from this study is unlikely to be unique to university students.

A third limitation is that these data are based on self-report. It would have been beneficial to assess sleep problems using an objective measure (e.g., actigraphy). Self-report measures, however, represent an important way to investigate individuals' *perceptions* of their sleep quality, the variable of interest in the present study. Second, a concern with using self-report data is that participants may provide responses that are socially desirable. However, given the variability in the responses among this sample, including high-risk scores, this may not be a concern.

A fourth limitation is that although we did collect data over time, these results should not be interpreted as causal effects. Rather, they suggest that groups of individuals at one point in time may display differing characteristics over time. Future researchers should examine whether interventions for sleep and/or emotion dysregulation help those displaying elevated levels of mental health problems as this would provide some evidence of cause and effect.

Finally, the current study focused only on self-reported depressive symptoms and alcohol use as these are two areas of wellbeing that are pertinent for university students. However, psychosocial adjustment comprises multiple aspects of life, so another area for future research would be to examine other indicators of adjustment such as social interactions, friendship quality, self-esteem, and stress.

Conclusions

The current study provides insight into specific co-occurrence patterns between sleep problems and emotion dysregulation. Future work should be conducted so researchers can examine whether these patterns of association remain stable over time, and whether changes in these patterns are associated with changes in health outcomes

(e.g., depressive symptoms). In other words, are these four groups of co-occurrence found throughout each year of university attendance, and do individuals remain in the same group over time? Knowledge of the stability of this co-occurrence would provide even more insight into how sleep problems and emotion dysregulation are associated with negative health outcomes over time.

Overall, the examination of the association between sleep problems and emotion dysregulation at a person-centered level in the current study provides novel information on how these adjustment difficulties differ across individuals and enhances the ability to assess their long-term links with negative outcomes such as self-reported depressive symptoms and alcohol use. University is an important time of transition and our results indicate that adjustment difficulties in the first year of university attendance can have long-lasting effects, particularly for students with co-occurring adjustment difficulties.

References

- Aldao, A., & Dixon-Gordon, K. L. (2014). Broadening the scope of research on emotion regulation strategies and psychopathology. *Cognitive Behaviour Therapy*. Taylor & Francis. <https://doi.org/10.1080/16506073.2013.816769>
- American College Health Association. (n.d.). Publications and reports: ACHA-NCHA II.
- Arnett, J. J. (2000). Emerging adulthood: A theory of development from the late teens through the twenties. *American Psychologist*, *55*(5), 469–480.
<https://doi.org/10.1037/0003-066X.55.5.469>
- Babson, K. A., Trainor, C. D., Feldner, M. T., & Blumenthal, H. (2010). A test of the effects of acute sleep deprivation on general and specific self-reported anxiety and depressive symptoms: An experimental extension. *Journal of Behavior Therapy and Experimental Psychiatry*, *41*, 297–303. <https://doi.org/10.1016/j.jbtep.2010.02.008>
- Baglioni, C., Battagliese, G., Feige, B., Spiegelhalder, K., Nissen, C., Voderholzer, U., ... Riemann, D. (2011). Insomnia as a predictor of depression: A meta-analytic evaluation of longitudinal epidemiological studies. *Journal of Affective Disorders*, *135*, 10–19. <https://doi.org/10.1016/j.jad.2011.01.011>
- Bastien, C. H., Vallieres, A., & Morin, C. M. (2001). Validation of the Insomnia Severity Index as an outcome measure for insomnia research. *Sleep Medicine*, *2*, 297–307.
[https://doi.org/10.1016/S1389-9457\(00\)00065-4](https://doi.org/10.1016/S1389-9457(00)00065-4)
- Bergman, L. R., & Magnusson, D. (1997). A person-oriented approach in research on developmental psychopathology. *Development and Psychopathology*, *9*, 291–319.
- Bromet, E. J. (2016). Past and future directions in psychosis research. In E. J. Bromet (Ed.), *Long-term Outcomes in Psychopathology Research: Rethinking the Scientific*

- Agenda* (pp. 3–14). New York, NY: Oxford University Press.
- Buboltz, W. C., Brown, F., & Soper, B. (2001). Sleep habits and patterns of college students: A preliminary study. *Journal of American College Health, 50*(3), 131–135.
- Center for Behavioral Health Statistics and Quality. (2015). *Behavioral health trends in the United States: Results from the 2014 National Survey on Drug Use and Health*. Retrieved from <http://www.samhsa.gov/data/>
- Collins, L. M., & Lanza, S. T. (2010). *Latent class and latent transition analysis: with applications in the social behavioral, and health sciences*. Hoboken, N.J: Wiley.
- Dvorak, R. D., Sargent, E. M., Kilwein, T. M., Stevenson, B. L., Kuvaas, N. J., & Williams, T. J. (2014). Alcohol use and alcohol-related consequences: Associations with emotion regulation difficulties. *The American Journal of Drug and Alcohol Abuse, 40*(2), 125–130. <https://doi.org/10.3109/00952990.2013.877920>
- Eaton, W. W., Smith, C., Ybarra, M., Muntaner, C., & Tien, A. (2004). Center for Epidemiologic Studies Depression Scale: Review and revision (CESD and CESD-R). In M. E. Maruish (Ed.), *The Use of Psychological Testing For Treatment Planning And Outcomes Assessment: Instruments For Adults* (3rd ed., pp. 363–377). Yahweh, NJ: Lawrence Erlbaum Associates Publishers.
- Erikson, E. H. (1968). *Identity: Youth and Crisis*. New York, NY: Norton.
- Espie, C. A., Broomfield, N. M., Macmahon, K. M. A., Macphee, L. M., & Taylor, L. M. (2006). The attention-intention-effort pathway in the development of psychophysiologic insomnia: A theoretical review. *Sleep Medicine Reviews, 10*, 215–245. <https://doi.org/10.1016/j.smr.2006.03.002>
- Fairholme, C. P., Nosen, E. L., Nillni, Y. I., Schumacher, J. A., Tull, M. T., & Coffey, S.

- F. (2013). Sleep disturbance and emotion dysregulation as transdiagnostic processes in a comorbid sample. *Behaviour Research and Therapy*, *51*, 540–546.
<https://doi.org/10.1016/j.brat.2013.05.014>
- Galambos, N. L., Barker, E. T., & Krahn, H. J. (2006). Depression, self-esteem, and anger in emerging adulthood: Seven-year trajectories. *Developmental Psychology*, *42*(2), 350–365. <https://doi.org/10.1037/0012-1649.42.2.350>
- Galambos, N. L., Dalton, A. L., & Maggs, J. L. (2009). Losing sleep over it: Daily variation in sleep quantity and quality in canadian students' first semester of university. *Journal of Research on Adolescence*, *19*(4), 741–761.
<https://doi.org/10.1111/j.1532-7795.2009.00618.x>
- Global status report on alcohol and health, 2014*. (2014). Geneva: World Health Organization.
- Gratz, K. L., & Roemer, L. (2004). Multidimensional assessment of emotion regulation and dysregulation: Development, factor structure, and initial validation of the Difficulties in Emotion Regulation Scale. *Journal of Psychopathology and Behavioral Assessment*, *26*(1), 41–54.
<https://doi.org/10.1023/B:JOBA.0000007455.08539.94>
- Gratz, K. L., & Tull, M. T. (2010). Emotion regulation as a mechanism of change in acceptance- and mindfulness-based treatments. In R. A. Baer (Ed.), *Assessing Mindfulness & Acceptance Processes in Clients: Illuminating the Theory & Practice of Change* (pp. 107–134). Oakland, CA: New Harbinger Publications, Inc.
- Gruber, R., & Cassoff, J. (2014). The interplay between sleep and emotion regulation: Conceptual framework empirical evidence and future directions. *Current Psychiatry*

Reports, 16, 500. <https://doi.org/10.1007/s11920-014-0500-x>

Hopp, H., Troy, A. S., & Mauss, I. B. (2011). The unconscious pursuit of emotion regulation: Implications for psychological health. *Cognition and Emotion*, 25(3), 532–545. <https://doi.org/10.1080/02699931.2010.532606>

Johnston, L. D., O'Malley, P. M., Bachman, J. G., & Schulenberg, J. E. (2006).

Monitoring the Future: National Survey Results on Drug Use, 1975-2006 - Volume I, Secondary School Students. Monitoring the Future (Vol. I). Bethesda, MD.

Retrieved from http://monitoringthefuture.org/pubs/monographs/vol1_2006.pdf

Jung, T., & Wickrama, K. A. S. (2008). An introduction to latent class growth analysis and growth mixture modeling. *Social and Personality Psychology Compass*, 2(1), 302–317.

Kairouz, S., Gliksman, L., Demers, A., & Adlaf, E. M. (2002). For all these reasons, I do...drink: A multilevel analysis of contextual reasons for drinking among Canadian undergraduates. *Journal of Studies on Alcohol*, 63(5), 600–608.

<https://doi.org/10.15288/jsa.2002.63.600>

Kuvaas, N. J., Dvorak, R. D., Pearson, M. R., Lamis, D. A., & Sargent, E. M. (2014).

Self-regulation and alcohol use involvement: A latent class analysis. *Addictive Behaviors*, 39(1), 146–152. <https://doi.org/10.1016/j.addbeh.2013.09.020>

Behaviors, 39(1), 146–152. <https://doi.org/10.1016/j.addbeh.2013.09.020>

Little, T. D. (2013). *Longitudinal Structural Equation Modeling*. New York, NY:

Guilford Press.

Markarian, S. A., Pickett, S. M., Deveson, D. F., & Kanona, B. B. (2013). A model of

BIS/BAS sensitivity, emotion regulation difficulties, and depression, anxiety, and

stress symptoms in relation to sleep quality. *Psychiatry Research*, 210(1), 281–286.

<https://doi.org/10.1016/j.psychres.2013.06.004>

- Masten, A. S., Faden, V. B., Zucker, R. A., & Spear, L. P. (2009). A developmental perspective on underage alcohol use. *Alcohol Research & Health, 32*(1), 3–15.
- Mauss, I. B., Troy, A. S., & LeBourgeois, M. K. (2013). Poorer sleep quality is associated with lower emotion-regulation ability in a laboratory paradigm. *Cognition & Emotion, 27*(3), 1–10. <https://doi.org/10.1080/02699931.2012.727783>
- Messman-Moore, T., Ward, R. M., Zerubavel, N., Chandley, R. B., & Barton, S. N. (2015). Emotion dysregulation and drinking to cope as predictors and consequences of alcohol-involved sexual assault: Examination of short-term and long-term risk. *Journal of Interpersonal Violence, 30*(4), 601–621. <https://doi.org/10.1177/0886260514535259>
- Morin, C. M. (1993). *Insomnia: Psychological assessment and management*. New York, NY: Guilford Press.
- Muthén, L. K., & Muthén, B. O. (n.d.). *Mplus user's guide*. (M. & Muthén, Ed.) (6th ed.). Los Angeles, CA.
- Nagin, D. S. (2005). *Group-based modeling of development*. Cambridge, MA: Harvard University Press.
- Nezlek, J. B., & Kuppens, P. (2008). Regulating positive and negative emotions in daily life. *Journal of Personality, 76*(3), 561–580. <https://doi.org/10.1111/j.1467-6494.2008.00496.x>
- Nolen-Hoeksema, S., & Aldao, A. (2011). Gender and age differences in emotion regulation strategies and their relationship to depressive symptoms. *Personality and Individual Differences, 51*(6), 704–708. <https://doi.org/10.1016/j.paid.2011.06.012>

- Nylund, K. L., Asparouhov, T., & Muthén, B. O. (2007). Deciding on the number of classes in latent class analysis and growth mixture modelling: A monte carlo simulation study. *STRUCTURAL EQUATION MODELING*, *14*(4), 535–569.
- Pearson, C., Janz, T., & Ali, J. (2013). *Health at a glance: Mental and substance use disorders in Canada. Statistics Canada*. Retrieved from <http://www.statcan.gc.ca/pub/82-624-x/2013001/article/11855-eng.pdf>
- Pickett, S. M., Barbaro, N., & Mello, D. (2015). The relationship between subjective sleep disturbance, sleep quality, and emotion regulation difficulties in a sample of college students reporting trauma exposure. *Psychological Trauma: Theory, Research, Practice, and Policy*.
- Radloff, L. S. (1977). The CES-D Scale: A self-report depression scale for research in the general population. *Applied Psychological Measurement*, *1*(3), 385–401.
- Ready, R. E., Marquez, D. X., & Akerstedt, A. (2009). Emotion in younger and older adults: Retrospective and prospective associations with sleep and physical activity. *Experimental Aging Research*, *35*(3), 348–368.
<https://doi.org/10.1080/03610730902922184>
- Sandru, C., & Voinescu, B. I. (2014). The relationship between emotion regulation, dysfunctional beliefs about sleep and sleep quality - An exploratory study. *Journal of Evidence-Based Psychotherapies*, *14*(2), 249–257.
- Schafer, J. L., & Graham, J. W. (2002). Missing data - Our view of the state of the art. *Psychological Methods*, *7*(2), 147–177.
- Srivastava, S., Tamir, M., McGonigal, K. M., John, O. P., & Gross, J. J. (2009). The social costs of emotional suppression: A prospective study of the transition to

college. *Journal of Personality and Social Psychology*, 96(4), 883–897.

<https://doi.org/10.1037/a0014755>

Tavernier, R., & Willoughby, T. (2014a). A longitudinal examination of the bidirectional association between sleep problems and social ties at university: The mediating role of emotion regulation. *Journal of Youth and Adolescence*, 1–14.

<https://doi.org/10.1007/s10964-014-0107-x>

Tavernier, R., & Willoughby, T. (2014b). Bidirectional associations between sleep (quality and duration) and psychosocial functioning across the university years.

Developmental Psychology, 50(3), 674–82. <https://doi.org/10.1037/a0034258>

Tempesta, D., Couyoumdjian, A., Curcio, G., Moroni, F., Marzano, C., De Gennaro, L., & Ferrara, M. (2010). Lack of sleep affects the evaluation of emotional stimuli.

Brain Research Bulletin, 82(1–2), 104–108.

<https://doi.org/10.1016/j.brainresbull.2010.01.014>

Thomas, G. (2012). Levels and patterns of alcohol use in Canada. Ottawa, ON: Canadian

Centre on Substance Abuse. Retrieved from <http://www.ccsa.ca/Resource>

[Library/CCSA-Patterns-Alcohol-Use-Policy-Canada-2012-en.pdf](http://www.ccsa.ca/Resource/Library/CCSA-Patterns-Alcohol-Use-Policy-Canada-2012-en.pdf)

Van Dam, N. T., & Earleywine, M. (2011). Validation of the Center for Epidemiologic Studies Depression Scale-Revised (CESD-R): Pragmatic depression assessment in the general population. *Psychiatry Research*, 186(1), 128–132.

<https://doi.org/10.1016/j.psychres.2010.08.018>

Vilagut G, Forero C. G., Barbaglia G, & Alonso J.(2016) Screening for depression in the general population with the center for epidemiologic studies depression (CES-D): A systematic review with meta-analysis. *PLoS One*, 11(5):1-17, doi:

10.1371/journal.pone.0155431

Willoughby, T. (2013). Frequency of alcohol use and level of binge drinking in a high school sample versus a separate university sample. *Unpublished Raw Data*.

Willoughby, T., Good, M., Adachi, P. J. C., Hamza, C., & Tavernier, R. (2013).

Examining the link between adolescent brain development and risk taking from a social-developmental perspective. *Brain and Cognition*, 83(3), 315–324.

<https://doi.org/10.1016/j.bandc.2013.09.008>

Wong, M. M., Brower, K. J., Nigg, J. T., & Zucker, R. A. (2010). Childhood sleep problems, response inhibition, and alcohol and drug outcomes in adolescence and young adulthood. *Alcohol Clin Exp Res*, 34(6), 1033–1044.

<https://doi.org/10.1111/j.1530-0277.2010.01178.x>

Chapter 5 - General Discussion and Conclusions

The main focus in this dissertation was to examine adjustment difficulties among university students, specifically the relationship among sleep problems, emotion dysregulation, depressive symptoms, alcohol use, and physical activity given their importance and prevalence throughout the university years (Bray & Born, 2004; Center for Behavioral Health Statistics and Quality, 2015; Deliens, Deforche, De Bourdeaudhuij, & Clarys, 2015; Johnston, O'Malley, Bachman, & Schulenberg, 2007; Pearson, Janz, & Ali, 2013; Willoughby, Good, Adachi, Hamza, & Tavernier, 2014). Although a plethora of cross-sectional and some experimental research has been conducted examining the associations among these factors, little work has examined temporal precedence (e.g., do sleep problems predict depressive symptoms, or do depressive symptoms predict sleep problems?) which is critical to understanding how these indicators of adjustment and well-being are associated across time. Thus, conducting longitudinal research in this area is of utmost importance and was the first goal of this study.

I also was interested in examining a potential mechanism through which sleep problems and adjustment (e.g., depressive symptoms, alcohol use, and physical activity) are related, namely emotion dysregulation. Emotion dysregulation has been linked to sleep problems (e.g., Cerolini, Ballesio, & Lombardo, 2015), physical activity (e.g., Ready, Marquez, & Akerstedt, 2009), alcohol use (e.g., Messman-Moore, Ward, Zerubavel, Chandley, & Barton, 2015), and depressive symptoms (e.g., Markarian, Pickett, Deveson, & Kanona, 2013), making it a potential mechanism through which these variables are associated over time.

To address these research questions, I conducted three studies. The first two studies focused on the role of emotion dysregulation as a potential link between sleep and physical activity over time (Study 1), and between sleep and depressive symptoms as well as alcohol use over time (Study 2). In Study 3, I focused on a person-centered approach which allowed me to examine heterogeneity (i.e., different patterns of association) in the relationship between sleep problems and emotion dysregulation, and how these patterns were associated with well-being in the short- and long-term. Across these three studies there were some consistent findings and also some unexpected findings which are outlined and synthesized in the following sections.

Sleep Problems

Past research has indicated that there might be bidirectional relationships between sleep problems and emotion dysregulation. However, the majority of this work tends to be concurrent (e.g., Hoag, Tennen, Stevens, Coman, & Wu, 2016; Pickett, Barbaro, & Mello, 2016), thus preventing an assessment of the direction of effects, or experimental (e.g., Yoo, Gujar, Hu, Jolesz, & Walker, 2007) in which both directions of effects are not assessed. Indeed, even past longitudinal research has tended to test either only one direction of association (e.g., O’Leary, Bylsma, & Rottenberg, 2016), or has not tested bidirectional relationships simultaneously (e.g. Tavernier & Willoughby, 2014).

In the current dissertation, both Studies 1 and 2 indicated that there were bidirectional relationships between sleep problems and emotion dysregulation. Specifically, 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. Thus, these results provide a direct test of

bidirectionality and also support past concurrent and experimental research that has suggested a bidirectional relationship between these two factors.

With regard to sleep and physical activity, past research has demonstrated inconsistent findings, with some researchers finding associations between them (e.g., Gerber, Brand, Holsboer-Trachsler, & Pühse, 2010; Kalak et al., 2012) and others finding no association between them (e.g., Mitchell et al., 2016; Youngstedt et al., 2003). In Study 1 of this dissertation, the results indicated that sleep problems were not directly associated with physical activity but instead were indirectly related to high, moderate and low levels of physical activity over time *through* emotion dysregulation. Further, only moderate levels of physical activity promoted fewer sleep problems over time through decreased emotion dysregulation. This finding of only an indirect effect helps shed light on why past research results in this area have been so mixed.

Study 2 indicated that sleep problems directly 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. Further, sleep problems also predicted more alcohol use over time controlling for previous alcohol use. Overall, the results across these studies indicate that sleep is associated with a variety of outcomes important throughout university. However, these associations are a mix of direct (e.g., sleep to depressive symptoms) and indirect effects (e.g., sleep problems predicting physical activity via emotion dysregulation).

Overall, these findings have important implications because they indicate that sleep quality is a significant issue for a variety of indicators of university adjustment. This knowledge is vital because many university students tend to focus on their academic

work and disregard the importance of sleep. In a study by Brown, Qin, and Esmail (2017), they examined university students' perceptions about their sleep quality and habits. In an open-ended question, the researchers also assessed general information students had regarding sleep patterns. The largest theme was that academic load and test scheduling created poor environments for obtaining enough sleep; this was followed by unhealthy lifestyles and bad habits [e.g., excessive screen time (i.e., phones), eating less nutritious food; Brown et al., 2017]. These results also are consistent with research by Agarwal, Eryuzlu, and Chawla (2014) and Hershner (2015) and suggest that looking for ways to facilitate better sleep habits among university students should be a priority.

Emotion Dysregulation

Like sleep, emotion dysregulation has been linked to a variety of adjustment indicators (Dragan, 2015; Fischer, Forthun, Pidcock, & Dowd, 2007; Nolen-Hoeksema & Aldao, 2011). In Study 1 of this dissertation, emotion dysregulation predicted lower levels of high, moderate, and low physical activity across time controlling for previous physical activity. In addition, moderate physical activity predicted less emotion dysregulation over time controlling for previous emotion dysregulation. In Study 2 of this dissertation, emotion dysregulation was bidirectionally related to 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.

Although past research has revealed mixed findings in the relationship between these two factors, these results are consistent with some previous work that has indicated these two adjustment indicators are related (e.g., Berking, Wirtz, Svaldi, & Hofmann, 2014).

In general, these findings indicate that emotion dysregulation plays an important role in the promotion of physical activity and also lower levels of depressive symptoms. With regard to physical activity, Gross (2002), has indicated that poor emotion regulation strategies – for example, inhibiting or suppressing emotions – are related to poor health outcomes (also see DeSteno, Gross, & Kubzansky, 2013 for a discussion). Specifically, Denollet et al. (1996) found that individuals with a history of heart attacks and who generally suppressed their emotions had higher mortality rates than those with a history of heart attacks who did not suppress their emotions. In this study, patients who had passed away displayed a variety of problematic health symptoms, but one was that they tended to exercise less than those who had not. Perhaps the relationship of emotion dysregulation with a variety of other health problems is a contributing factor to exercising less frequently. With regard to depressive symptoms, these results indicate that these two factors may, indeed, be related, and provides more support to previous work that has found this relationship (e.g., Berking et al., 2014). Clearly emotion dysregulation plays a valuable role in the promotion of well-being.

Mechanisms Across Time

Given the link between emotion dysregulation and sleep, physical activity and depressive symptoms, I tested whether it might be a mechanism through which these factors are related. Throughout Studies 1 and 2, emotion dysregulation did, indeed, act as a mechanisms linking sleep problems and depressive symptoms over time, as well as sleep problems and physical activity over time. However, given the bidirectional relationship between sleep problems and emotion dysregulation, testing sleep problems as a potential mechanism also was important. In Study 1 this association was not assessed

given that sleep was not directly predictive of physical activity. In Study 2, however, results indicated that sleep problems also provided a mechanism by which emotion dysregulation was associated with depressive symptoms over time.

Again, these results have a variety of implications. First, given the findings throughout the current studies that there is a bidirectional relationship between sleep problems and emotion dysregulation, it is important for researchers to consider a priori whether there might be multiple mechanisms by which these factors are related to adjustment. For example, I found that sleep problems and emotion dysregulation each provided a mechanism through which the other was associated with adjustment difficulties. Second, examining mechanisms by which various indicators of adjustment are related provide alternative explanations for why certain factors may be related, and/or why previous research has sometimes not found significant associations.

Short- and Long-term Effects

Study 3 took a different approach to examining sleep problems and well-being. Given that sleep and emotion dysregulation are bidirectionally related (Study 1 and Study 2), and are considered to be transdiagnostic indicators of a variety of mental health problems (Fairholme et al., 2013), I conducted a person-centered analysis (i.e., a latent class analysis) to examine heterogeneity in the relationship between sleep problems and emotion dysregulation. Overall, I found four patterns of associations: 1) individuals with high levels of sleep problems and emotion dysregulation, 2) individuals with high levels of sleep problems only, 3) individuals with high levels of emotion dysregulation only, and 4) individuals with low levels of both sleep problems and emotion dysregulation. Individuals in Group 1 demonstrated the highest level of depressive symptoms both in the

short-term (i.e., concurrent with the year of group membership), but also 4 years later. Individuals in Group 4 demonstrated the lowest level of depressive symptoms at both time points. Individuals in Groups 2 and 3 demonstrated moderate levels of depressive symptoms in the short-term but were not different from Group 1 – over the long term. Thus, individuals with co-occurring difficulties appear to have elevated levels of depressive symptoms both in the short- and long-term.

In general, the results from Study 3 indicate that these variables are related over an extended period of time. This is also evident in Study 1 in which sleep, emotion dysregulation, and physical activity were associated across three years, and in Study 2 in which sleep, emotion dysregulation, depressive symptoms, and alcohol use were associated across five years. This is important to note because these results suggest that difficulties in sleep and emotion dysregulation have lasting effects, especially for students who experience multiple difficulties (e.g., the high co-occurrence group in Study 3). This finding has implications for individuals interested in aiding students who experience difficulties in adjustment - these results help identify groups of students who should be targeted for intervention strategies in university.

Predictors Versus Outcomes

In the conclusion of Study 2, one of the main messages was that it is difficult to frame indicators of adjustment as either predictors *or* outcomes given the complex and bidirectional relationships that were evident. Although this was not always the case in this dissertation (e.g., I found mostly unidirectional relationships among sleep problems, emotion dysregulation, and physical activity in Study 1), it appears that indicators more closely tied to mental health may be mutually reinforcing. This is important for those who

are interested in reducing difficulties in adjustment because it provides more areas to target, rather than searching for a single “cause” of problems in well-being.

This idea is further tied to the co-occurring nature of sleep problems and emotion dysregulation. Both sleep problems and emotion dysregulation are underlying factors in a variety of mental health problems (e.g., anxiety and depression, Fairholme et al. 2013). However, the results in Study 3 of this dissertation also indicate that there may be varying patterns of association between these two adjustment indicators. Specifically, some individuals may display high levels of both sleep problems and emotion dysregulation, low levels of both, or symptoms of only one indicator. Each of these varying patterns of association have different relationships with depressive symptoms and, to some extent, alcohol use. One key result from Study 3 was that individuals who were high on both sleep problems and emotion dysregulation displayed elevated levels of depressive symptoms both at a concurrent time point, but also four years later. This finding also supports the idea of mutual reinforcement across time and that these indicators cannot only be framed as predictors or outcomes. Moreover, these results are consistent with past research that shows that individuals with comorbid difficulties tend to fare worse than individuals with just one difficulty (e.g., Kranzler, Del Boca, & Rounsaville, 1996).

Strengths and Limitations

The studies throughout this dissertation have a variety of strengths. The first is that two approaches were taken to examine associations between sleep problems, emotion dysregulation, and adjustment throughout university. Studies 1 and 2 had a variable-centered approach and utilized the strengths of an auto-regressive cross-lag path analysis. A variable-centered approach allows for the examination of associations between

variables over time but does not allow for the examination of distinct patterns of association. Study 3 took a person-centered approach to address this issue, allowing me to investigate heterogeneity in the relationship between sleep problems and emotion dysregulation over time.

A second strength is the consistency of associations across these studies. Both Studies 1 and 2 found a bidirectional relationship between sleep problems and emotion dysregulation although the models in which these two factors were integrated were different, in that each model incorporated different variables which can alter the patterns of association). Further, both models in Studies 1 and 2 were invariant across time. This indicates that the patterns of association between these variables did not change depending on the wave of measurement. However, perhaps continuing to follow these participants over time may reveal differences in association given that most students would have graduated after the fifth year of university. This is interesting given the fact that emerging adulthood is often considered a period of change and transition (e.g., Arnett 2000, 2001). However, these results tend to speak to the stability of associations across this period of life. Perhaps emerging adulthood could be more characterized by life transitions (e.g., moving away from home), whereas the relationships between these indicators of adjustment are more stable. To glean insight into whether emerging adulthood *invites* change would require examining individuals throughout high school, into university and then into the workforce.

A third strength is that these studies comprise a large sample followed over a number of years. This design allows for a variety of analyses to be conducted with enough power to find effects. This strength, however, must be balanced with its limitations. It is

important to note that the magnitude of the relationships found in this dissertation were small – especially in Studies 1 and 2. Given the study designs, however, this is not surprising (Adachi & Willoughby, 2015). For example, when conducting auto-regressive cross-lag path analyses, you are controlling for concurrent associations (i.e., correlations between the variables within each time point), stability across time of each variable (i.e., controlling for previous scores, or the autoregressive path), covariate effects, and also all other predictive paths in the model (see Figure 5-1 for an illustration). Moreover, Adachi and Willoughby (2015) indicate that including the autoregressive path – or the stability of a variable across time – if it is strong, can reduce the possibility of finding a large effect (see Figure 5-2). It is important to note, however, that although the effects across time might be small, they can still be seen as meaningful.

One caveat that also should be mentioned is that these cross-lag results are unique to the model in which it is tested. Therefore, if the model is altered or if multiple other variables are included thereby creating an even more complex model, patterns of associations may differ. Finally, a limitation of this work is that it comprises only university students. It could be that these relationships differ for individuals who do not attend university (see below). In addition, given that sleep, emotion dysregulation, physical activity, depressive symptoms and alcohol use are important indicators of adjustment across the lifespan, noting the patterns of association across a variety of age groups would be key (see below in Future Research).

Future Research

These studies provide important insight into university adjustment and address limitations and gaps that were evident throughout the literature. However, these studies

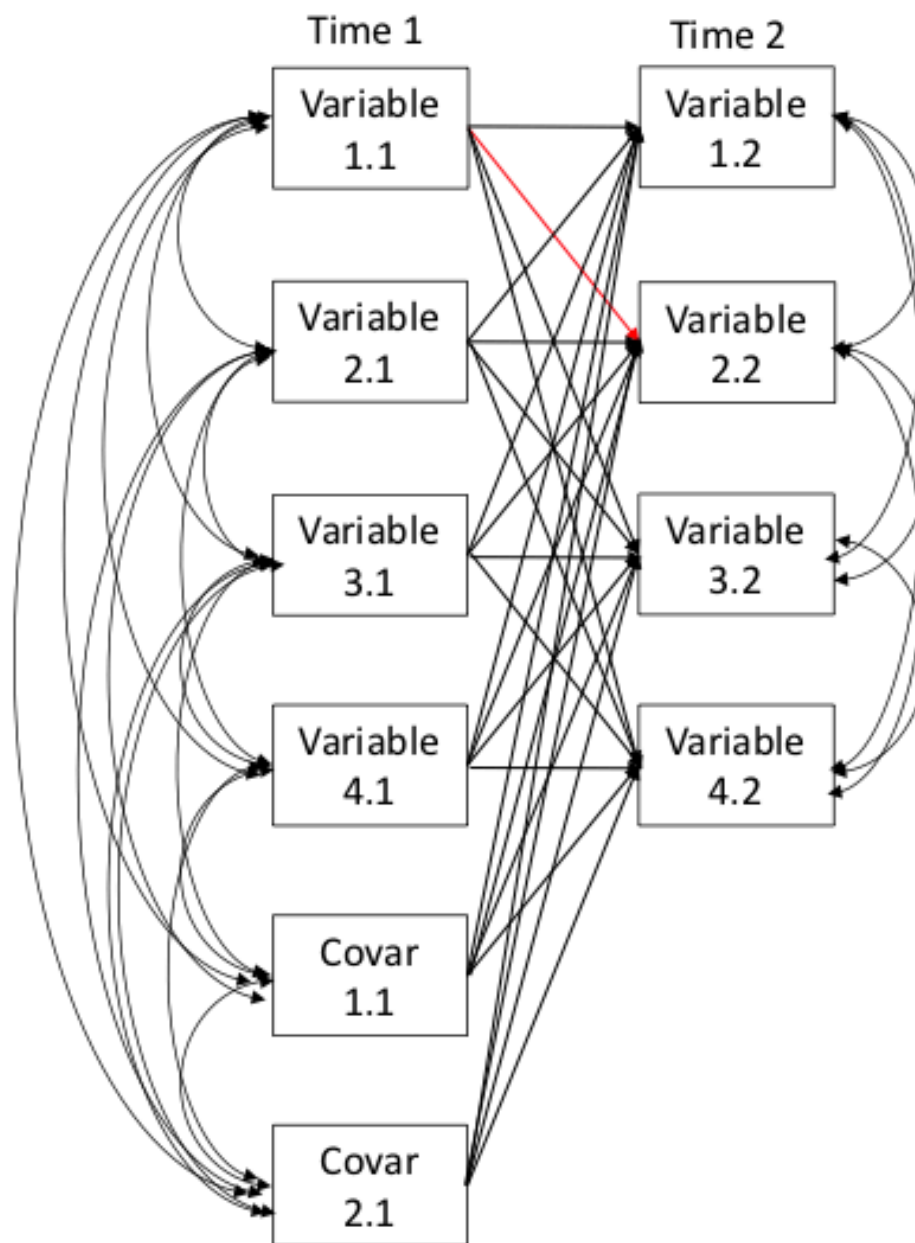
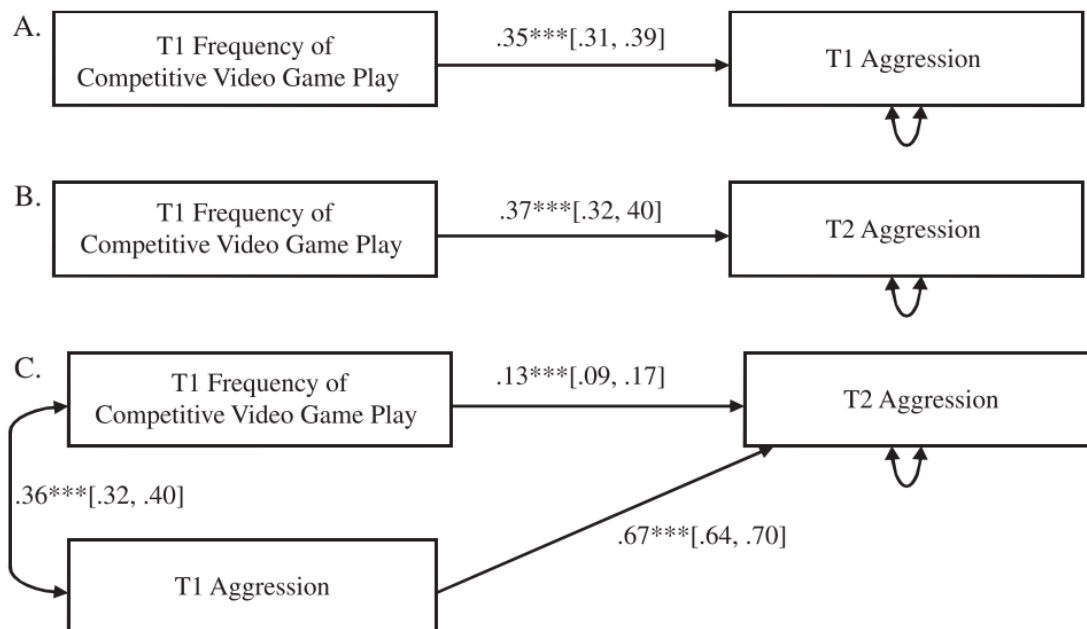


Figure 5-1. An illustration of paths involved in a saturated autoregressive cross-lag path model. As an example, the unique effect of Variable 1.1 on Variable 2.2 (the red path) is controlling for a variety of other associations. Specifically, the effect of Variable 1.1 on Variable 2.2 is controlling for: previous scores on variable 2.2. (i.e., controlling for 2.1), correlations between Variable 2.1 and all other Time 1 variables, and all other predictive paths to variable 2.2 (i.e., controlling for Variable 3.1, 4.1 Covar 1.1 and Covar 2.1).



Notes. T1 = Time 1; T2 = Time 2. Standardized coefficients (95% confidence intervals are in brackets) are reported. * $<.05$, ** $<.01$, *** $<.001$.

Figure 5-2. Figure from Adachi & Willoughby (2015). This figure displays results for concurrent associations between the predictor and outcome (A.), longitudinal associations between the predictor and outcome (B), and the longitudinal effect (C) controlling for the concurrent T1 association and the autoregressive effect. Adachi and Willoughby (2015) explain the figure as follows:

“First, we examine the concurrent association between T1 frequency of competitive video game play and T1 aggression (see Figure 1A). The bivariate r is .35 for the predictive effect of T1 frequency of competitive video game play on T1 aggression. Next, we examine the longitudinal association between T1 frequency of competitive video game play and T2 aggression without controlling for stability effects (see Figure 1B). Similar to the concurrent association, the bivariate r is .37 for the predictive effect of T1 frequency of competitive video game play on T2 aggression (again, when there are only two variables in the

model, the bivariate r is equal to the value of β). Finally, we conduct an autoregressive path analysis to examine the longitudinal association between T1 frequency of competitive video game play and T2 aggression, controlling for stability effects (see Figure 1C). The stability path from T1 aggression to T2 aggression is $\beta = .67$, and the concurrent association between T1 frequency of competitive video game play and T1 aggression is bivariate $r = .36$. Thus, the indirect path from T1 frequency of competitive video game play on T2 aggression through T1 aggression is $.67 \times .36 = .24$. Controlling for stability effects, therefore, removes variance (i.e., .24) in T2 aggression that is shared with T1 frequency of competitive video game play and reduces the predictive effect of T1 frequency of competitive video game play on T2 aggression by almost 2/3, from bivariate $r = .37$ to $\beta = .13$. Therefore, controlling for stability in aggression dramatically reduces the magnitude of the effect size of another predictor of T2 aggression,” (pg.120-121).

also present more research questions that should be addressed in the future. One area for future research would be to examine these patterns of association throughout a longer

time span. Given that there now are seven waves of data available in this dataset, it is possible that a transition to work may alter wellbeing (e.g., Haase, Heckhausen, & Silbereisen, 2012) and perhaps the patterns of association between these variables. For example, when we take results from Study 3 into account, perhaps individuals who displayed either sleep problems or emotion dysregulation will undergo another point during which adjustment difficulties are evident again and display increases in depressive symptoms.

Another area for future research would be to examine how group membership – or patterns of heterogeneity between sleep problems and emotion dysregulation – may change across time. For example, a latent transition analysis would indicate whether these four patterns of association between sleep problems and emotion dysregulation remain stable across time, and also would indicate how stable individuals are within these groups across time (e.g., do they maintain high levels of sleep problems and emotion dysregulation across time?). If the result was that individuals tend to switch between groups (for example, display high levels of both sleep problems and emotion dysregulation at Time 1 and then only display sleep problems later on), it would be important to examine what other factors predict this change in group membership.

Finally, one last future direction would be to examine these patterns of association across other samples. One group to examine would be young adults who do not attend university. Students who attend university tend to have higher levels of alcohol use than individuals who do not go to university (O'Malley & Johnston, 2002) and may have higher levels of depressive symptoms as well, although results tend to be inconsistent in this area (Blanco & Okuda, 2008; Ibrahim, Kelly, Adams, & Glazebrook, 2013). Thus, it

would be important to examine whether the patterns of association found in this dissertation hold across a sample of individuals that are the same age but have chosen a different life trajectory than those included in the current studies. A second group of individuals to examine would be older adults. Currently I have one wave of data available that includes each of the measures used throughout this dissertation. However, given the amount of evidence showing bidirectional associations between these factors, it does not seem pertinent to run a structural equation model with concurrent data and try to assess similar research questions as were assessed in the present set of studies. Rather, it may be better to collect a second wave of data and then run these analyses to ascertain whether similar patterns of association are found in this age group as they are in a sample of undergraduate students.

Conclusion

In conclusion, this set of studies indicates that two common problems in university – sleep and emotion dysregulation – are bidirectionally related over time and also sometimes are co-occurring. The current results also indicate that problems experienced early on in university may have lasting effects. For example, the patterns of association between sleep, emotion dysregulation, alcohol use, sleep problems and exercise were consistent across all periods of time. Further, individuals with the co-occurrence of high levels of sleep problems and emotion dysregulation demonstrated poorer long-term outcomes than individuals with only one adjustment difficulty or no difficulties. Thus, these areas of adjustment should be targeted by those involved with aiding university students throughout this time of transition. Further, given the bidirectional nature of many

of the associations found throughout these studies, multiple areas surrounding students' lives can be targeted when seeking to promote healthy outcomes for young adults.

References

- Adachi, P., & Willoughby, T. (2015). Interpreting effect sizes when controlling for stability effects in longitudinal autoregressive models: Implications for psychological science. *European Journal of Developmental Psychology, 12*(1), 116–128. <https://doi.org/10.1080/17405629.2014.963549>
- Agarwal, A., Eryuzlu, L., & Chawla, K. (2014). Sleep Deprivation: Student Perceptions and its Relationship to Cardiovascular Disease. *University of Toronto Medical Journal, 92*(2), 34–38. Retrieved from <http://utmj.org/index.php/UTMJ/article/view/1542>
- Berking, M., Wirtz, C. M., Svaldi, J., & Hofmann, S. G. (2014). Emotion regulation predicts symptoms of depression over five years. *Behaviour Research and Therapy, 57*(1), 13–20. <https://doi.org/10.1016/j.brat.2014.03.003>
- Blanco, C., & Okuda, M. (2008). Mental health of college students and their non-college-attending peers. *Arch Gen Psychiatry, 65*(12), 1429–1437. <https://doi.org/10.1001/archpsyc.65.12.1429>.
- Bray, S. R., & Born, H. A. (2004). Transition to University and Vigorous Physical Activity: Implications for Health and Psychological Well-Being. *Journal of American College Health, 52*(June), 181–188. <https://doi.org/10.3200/JACH.52.4.181-188>
- Brown, C., Qin, P., & Esmail, S. (2017). “Sleep? Maybe later...” A cross-campus survey of university students and sleep practices. *Education Sciences, 7*(3), 66. <https://doi.org/10.3390/educsci7030066>
- Buboltz, W. C., Brown, F., & Soper, B. (2001). Sleep habits and patterns of college

- students: A preliminary study. *Journal of American College Health*, 50(3), 131–135.
- Center for Behavioral Health Statistics and Quality. (2015). *Behavioral health trends in the United States: Results from the 2014 National Survey on Drug Use and Health*. Retrieved from <http://www.samhsa.gov/data/>
- Cerolini, S., Ballezio, A., & Lombardo, C. (2015). Insomnia and emotion regulation: Recent findings and suggestions for treatment. *Journal of Sleep Disorders and Management*, 1(1), 1–5.
- Collins, A., & van Dulmen, M. (2006). Friendships and romance in emerging adulthood: Assessing distinctiveness in close relationships. In J. J. Arnett & J. L. Tanner (Eds.), *Emerging Adults in America: Coming of Age in the 21st Century* (pp. 219–234). Washington, DC: American Psychological Association.
- <https://doi.org/10.1037/11381-009>
- Cote, J. E. (2006). Emerging adulthood as an institutionalized moratorium: Risks and benefits to identity formation. In J. J. Arnett & J. L. Tanner (Eds.), *Emerging Adults in America Coming of age in the 21st century Arnett* (pp. 85–116). Washington, DC: American Psychological Association. <https://doi.org/10.1037/11381-004>
- Deliens, T., Deforche, B., De Bourdeaudhuij, I., & Clarys, P. (2015). Determinants of physical activity and sedentary behaviour in university students: a qualitative study using focus group discussions. *BMC Public Health*, 15, 201.
- <https://doi.org/10.1186/s12889-015-1553-4>
- Denollet, J., Rombouts, H., Gillebert, T. C., Brutsaert, D. L., Sys, S. U., Brutsaert, D. L., & Stroobant, N. (1996). Personality as independent predictor of long-term mortality in patients with coronary heart disease. *The Lancet*, 347(8999), 417–421.

- DeSteno, D., Gross, J. J., & Kubzansky, L. (2013). Affective science and health: The importance of emotion and emotion regulation. *Health Psychology, 32*(5), 474. <https://doi.org/10.1037/a0030259>
- Dragan, M. (2015). Difficulties in emotion regulation and problem drinking in young women: The mediating effect of metacognitions about alcohol use. *Addictive Behaviors, 48*, 30–35. <https://doi.org/10.1016/j.addbeh.2015.04.008>
- Fairholme, C. P., Nosen, E. L., Nillni, Y. I., Schumacher, J. A., Tull, M. T., & Coffey, S. F. (2013). Sleep disturbance and emotion dysregulation as transdiagnostic processes in a comorbid sample. *Behaviour Research and Therapy, 51*(9), 540–546. <https://doi.org/10.1016/j.brat.2013.05.014>
- Fischer, J. L., Forthun, L. F., Pidcock, B. W., & Dowd, D. A. (2007). Parent relationships, emotion regulation, psychosocial maturity and college student alcohol use problems. *Journal of Youth and Adolescence, 36*(7), 912–926. <https://doi.org/10.1007/s10964-006-9126-6>
- Gerber, M., Brand, S., Holsboer-Trachsler, E., & Pühse, U. (2010). Fitness and exercise as correlates of sleep complaints: Is it all in our minds? *Medicine & Science in Sports & Exercise, 42*(5), 893–901. <https://doi.org/10.1249/MSS.0b013e3181c0ea8c>
- Gross, J. J. (2002). Emotion regulation: Affective, cognitive, and social consequences. *Psychophysiology, 39*, 281–291. <https://doi.org/10.1017.S0048577201393198>
- Haase, C. M., Heckhausen, J., & Silbereisen, R. K. (2012). The interplay of occupational motivation and well-being during the transition from university to work. *Developmental Psychology, 48*(6), 1739–1751. <https://doi.org/10.1037/a0026641>
- Hershner, S. (2015). Is sleep a luxury that college students cannot afford? *Sleep Health,*

- I*(1), 13–14. <https://doi.org/10.1016/j.sleh.2014.12.006>
- Hoag, J. R., Tennen, H., Stevens, R. G., Coman, E., & Wu, H. (2016). Affect, emotion dysregulation, and sleep quality among low-income women. *Sleep Health, 2*, 283–288. <https://doi.org/10.1016/j.sleh.2016.08.006>
- Ibrahim, A. K., Kelly, S. J., Adams, C. E., & Glazebrook, C. (2013). A systematic review of studies of depression prevalence in university students. *Journal of Psychiatric Research, 47*(3), 391–400. <https://doi.org/10.1016/j.jpsychires.2012.11.015>
- Johnston, L. D., O'Malley, P. M., Bachman, J. G., & Schulenberg, J. E. (2007). *Monitoring the Future: National Survey Results on Drug Use, 1975-2006 - Volume I, Secondary School Students. Monitoring the Future* (Vol. I). Bethesda, MD. Retrieved from http://monitoringthefuture.org/pubs/monographs/vol1_2006.pdf
- Kalak, N., Gerber, M., Kirov, R., Mikoteit, T., Yordanova, J., Pühse, U., ... Brand, S. (2012). Daily morning running for 3 weeks improved sleep and psychological functioning in healthy adolescents compared with controls. *Journal of Adolescent Health, 51*, 615–622. <https://doi.org/10.1016/j.jadohealth.2012.02.020>
- Kranzler, H. R., Del Boca, F. K., & Rounsaville, B. J. (1996). Comorbid psychiatric diagnosis predicts three-year outcomes in alcoholics: a posttreatment natural history study. *Journal of Studies on Alcohol, 57*(6), 619–626. <https://doi.org/10.15288/jsa.1996.57.619>
- Markarian, S. A., Pickett, S. M., Deveson, D. F., & Kanona, B. B. (2013). A model of BIS/BAS sensitivity, emotion regulation difficulties, and depression, anxiety, and stress symptoms in relation to sleep quality. *Psychiatry Research, 210*(1), 281–286. <https://doi.org/10.1016/j.psychres.2013.06.004>

- Messman-Moore, T., Ward, R. M., Zerubavel, N., Chandley, R. B., & Barton, S. N. (2015). Emotion dysregulation and drinking to cope as predictors and consequences of alcohol-involved sexual assault: Examination of short-term and long-term risk. *Journal of Interpersonal Violence, 30*(4), 601–621. <https://doi.org/10.1177/0886260514535259>
- Mitchell, J. A., Godbole, S., Moran, K., Murray, K., James, P., Laden, F., ... Glanz, K. (2016). *No Evidence of Reciprocal Associations between Daily Sleep and Physical Activity. Medicine and science in sports and exercise.* <https://doi.org/10.1249/MSS.0000000000001000>
- Nolen-Hoeksema, S., & Aldao, A. (2011). Gender and age differences in emotion regulation strategies and their relationship to depressive symptoms. *Personality and Individual Differences, 51*(6), 704–708. <https://doi.org/10.1016/j.paid.2011.06.012>
- O’Leary, K., Bylsma, L. M., & Rottenberg, J. (2016). Why might poor sleep quality lead to depression? A role for emotion regulation. *Cognition and Emotion, 0*(0), 1–9. <https://doi.org/10.1080/02699931.2016.1247035>
- O’Malley, P. M., & Johnston, L. D. (2002). Epidemiology of alcohol and other drug use among American college students. *Journal of Studies on Alcohol, Supplement, (s14)*, 23–39. <https://doi.org/10.15288/jsas.2002.s14.23>
- Pearson, C., Janz, T., & Ali, J. (2013). *Health at a glance: Mental and substance use disorders in Canada. Statistics Canada.* Retrieved from <http://www.statcan.gc.ca/pub/82-624-x/2013001/article/11855-eng.pdf>
- Pickett, S. M., Barbaro, N., & Mello, D. (2016). The relationship between subjective sleep disturbance, sleep quality, and emotion regulation difficulties in a sample of

- college students reporting trauma exposure. *Psychological Trauma: Theory, Research, Practice, and Policy*, 8(1), 25–33. <https://doi.org/10.1037/tra0000064>
- Ready, R. E., Marquez, D. X., & Akerstedt, A. (2009). Emotion in younger and older adults: Retrospective and prospective associations with sleep and physical activity. *Experimental Aging Research*, 35(3), 348–368. <https://doi.org/10.1080/03610730902922184>
- Srivastava, S., Tamir, M., McGonigal, K. M., John, O. P., & Gross, J. J. (2009). The social costs of emotional suppression: A prospective study of the transition to college. *Journal of Personality and Social Psychology*, 96(4), 883–897. <https://doi.org/10.1037/a0014755>
- Tavernier, R., & Willoughby, T. (2014). A longitudinal examination of the bidirectional association between sleep problems and social ties at university: The mediating role of emotion regulation. *Journal of Youth and Adolescence*, 1–14. <https://doi.org/10.1007/s10964-014-0107-x>
- Willoughby, T., Good, M., Adachi, P. J. C., Hamza, C., & Tavernier, R. (2014). Examining the link between adolescent brain development and risk taking from a social-developmental perspective (reprinted). *Brain and Cognition*, 89, 70–8. <https://doi.org/10.1016/j.bandc.2014.07.006>
- Yoo, S. S., Gujar, N., Hu, P., Jolesz, F. a., & Walker, M. P. (2007). The human emotional brain without sleep - a prefrontal amygdala disconnect. *Current Biology*, 17(20), 877–878. <https://doi.org/10.1016/j.cub.2007.08.007>
- Youngstedt, S. D., Perlis, M. L., O'Brien, P. M., Palmer, C. R., Smith, M. T., Orff, H. J., & Kripke, D. F. (2003). No association of sleep with total daily physical activity in

normal sleepers. *Physiology and Behavior*, 78, 395–401.

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Appendix A: Demographics

1. Are you male or female? Male Female

2. What is your birth date? _____years _____month _____day

3. What is the highest level of education that your MOTHER/STEPMOTHER (female guardian) whom you have lived with the MOST has completed? (If more than one mother, answer for one of them or if you have no contact with your mother/stepmother or female guardian please skip to Question 4 below)
 - Did not finish high school
 - Finished high school
 - Some college, university, or apprenticeship program
 - Completed a college/apprenticeship diploma (e.g., electrician) and/or technical diploma (i.e., graphic design, hair dressing)
 - Completed a university undergraduate degree
 - Completed a professional degree (e.g., masters, PhD, medical doctor, lawyer)

4. What is the highest level of education that your FATHER/STEPFATHER (male guardian) whom you have lived with the MOST has completed? (If more than one father, answer for one of them or if you have no contact with your father/stepfather or male guardian please skip)
 - Did not finish high school
 - Finished high school
 - Some college, university, or apprenticeship program
 - Completed a college/apprenticeship diploma (e.g., electrician) and/or technical diploma (i.e., graphic design, hair dressing)
 - Completed a university undergraduate degree
 - Completed a professional degree (e.g., masters, PhD, medical doctor, lawyer)

5. Were you born in Canada? Yes No

Appendix B: Sports Clubs and Exercise

Sport Club Involvement

1. Since September 2010 (e.g., the start of this academic year), how often have you done the following:

	Never	Seldom	About once a month	2-3 times a month	About once a week	Several times a week
a) Participated in sports clubs.....	... <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> ...

Physical Activity

1. Indicate how many times in the LAST MONTH you participated in a physical activity, on your own or with a team, including school time.

	Every day	A few times a week	A few times a month	Once	Not at all
a) High-intensity physical activity (e.g., running, soccer, hockey, swimming, etc. to a point of heavy sweating, heavy breathing).....	... <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> ...
b) Medium-intensity physical activity (e.g., baseball, jogging, skating, etc. to a point of some sweating, faster than normal breathing)....	... <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> ...
c) Low-intensity physical activity (e.g., bowling, curling, walking, etc. to a point of little sweating, normal breathing).....	... <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> ...

Appendix C: Sleep Problems

Sleep problems were assessed using an adapted version of the Insomnia Severity Index (ISI; Morin, 1993). Item 3 was recoded to have a range of 1 to 5 so all variables were on the same scale.

1. Please answer whether you have any problems with the following:

	No Problem	Mild	Moderate	Severe	Very Severe Problem
a) Difficulty falling asleep.....	...□...	...□...	...□...	...□...	...□...
b) Difficulty staying asleep.....	...□...	...□...	...□...	...□...	...□...
c) Problem waking up too early.....	...□...	...□...	...□...	...□...	...□...
d) Problem staying awake.....	...□...	...□...	...□...	...□...	...□...

2. How satisfied are you with your sleep pattern?

- Very satisfied
- Satisfied
- Neither satisfied nor dissatisfied
- Dissatisfied
- Very dissatisfied

3. To what extent do you think your sleep patterns interfere with your daily functioning (daytime fatigue, ability to perform daily tasks, concentration, memory, mood, etc.?)

- Rarely interferes
- Sometimes interferes
- Often interferes
- Very often interferes

Appendix D: Emotion Dysregulation

Emotion dysregulation was measured in all three studies with six items from the Difficulties in Emotion Regulation Scale (DERS; Gratz & Roemer, 2004). The items and response options are outlined below.

1. Please indicate how often the following statements apply to you:

	Almost never	Sometimes	About half the time	Most of the time	Almost always
a) When I'm upset or stressed, I have difficulty concentrating.....	...□...	...□...	...□...	...□...	...□...
b) When I'm upset or stressed, I have difficulty thinking about anything else.....	...□...	...□...	...□...	...□...	...□...
c) When I'm upset or stressed, I can still get things done.....	...□...	...□...	...□...	...□...	...□...
d) When I'm upset or stressed, I believe that wallowing in it is all I can do.....	...□...	...□...	...□...	...□...	...□...
e) When I'm upset or stressed, I know that I can find a way to eventually feel better.....	...□...	...□...	...□...	...□...	...□...
f) When I'm upset or stressed, I start to feel very bad about myself.....	...□...	...□...	...□...	...□...	...□...

Appendix E: Alcohol Use

Alcohol use was assessed using one item:

1. On average, when you are drinking alcohol, about how many drinks do you have?

- Less than 1 drink
- 1 drink
- 2-3 drinks
- 4-6 drinks
- 7-10 drinks
- Over 10 drinks

Appendix F: Depressive Symptoms

Depressive symptoms were measured in all three studies using the The Center for Epidemiological Depression –Revised Scale (Eaton, Smith, Ybarra, Muntaner, & Tien, 2004; Radloff, 1977; Van Dam & Earleywine, 2011). Although there are 20 items total, we never included Item K (“My sleep was restless”) in our analyses as to not inflate the correlation between sleep problems and depressive symptoms.

1. Fill in the answer that best describes how often you felt or behaved this way
DURING THE PAST TWO WEEKS

	None of the time (Less than 1 day)	Rarely (1-2 days)	Some of the time (3-5 days)	Occasionally (6-9 days)	Most of the time (10-14 days)
a) I was happy.....	...□...	...□...	...□...	...□...	...□...
b) I did not feel like eating; my appetite was poor.....	...□...	...□...	...□...	...□...	...□...
c) I felt that I could not stop feeling sad, even with help from my family and friends.	...□...	...□...	...□...	...□...	...□...
d) I felt that I was just as good as other people.....	...□...	...□...	...□...	...□...	...□...
e) I had trouble keeping my mind on what I was doing..	...□...	...□...	...□...	...□...	...□...
f) I felt depressed.....	...□...	...□...	...□...	...□...	...□...
g) I felt that everything I did was an extra effort.....	...□...	...□...	...□...	...□...	...□...
h) I felt hopeful about the future.....	...□...	...□...	...□...	...□...	...□...
i) I thought my life had been a failure.....	...□...	...□...	...□...	...□...	...□...
j) I felt fearful.....	...□...	...□...	...□...	...□...	...□...
k) My sleep was restless.....	...□...	...□...	...□...	...□...	...□...
l) I was bothered by things that usually don't bother me.	...□...	...□...	...□...	...□...	...□...
m) I talked less than usual.....	...□...	...□...	...□...	...□...	...□...
n) I felt lonely.....	...□...	...□...	...□...	...□...	...□...
o) People were unfriendly.....	...□...	...□...	...□...	...□...	...□...
p) I felt like doing nothing....	...□...	...□...	...□...	...□...	...□...
q) I had crying spells.....	...□...	...□...	...□...	...□...	...□...
r) I felt sad.....	...□...	...□...	...□...	...□...	...□...
s) I felt that people disliked me.....	...□...	...□...	...□...	...□...	...□...
t) I enjoyed life.....	...□...	...□...	...□...	...□...	...□...

Appendix G: Consent form

Project Title: Stressed @ Brock?

Principal Investigator: Teena Willoughby (Professor)
 Department of Psychology, Brock University
 Email: twilloug@brocku.ca; Phone: 905-688-5550, ext 5474

INVITATION.

You are invited to participate in a study that involves research. The purpose of this study is to explore stress, coping, and academic achievement in undergraduate students. We are interested in looking at factors that both contribute to and reduce stress, as well as promote academic success during the transition to university. We are particularly interested in what happens over time, as students go through university.

WHAT'S INVOLVED

As a participant, you will be fill out a survey assessing aspects of your university experience that create and reduce stress, as well as questions that assess mental health, such as academic pressures, depression, anxiety, suicide ideation, self-harming behaviors, spirituality, personality, and coping. Participation will take approximately 60 minutes of your time. In addition to completing the questionnaire, your participation also involves giving your consent to allow the researchers to compare your responses with your academic records at Brock (university and high school course selection and grades, course withdrawals, and a yes or no to whether there have been any suspensions). Records will be accessed annually throughout undergraduate studies, at the end of each winter term each year you are registered at Brock.

POTENTIAL BENEFITS AND RISKS

Benefits of participation include either (a) the payment of \$10 or (b) proof of one hour research participation for credit in any one course that offers such credit, as well as the experience of taking part in psychological research. You will also get the opportunity to reflect on your life and your experiences in a confidential manner. The only anticipated risks associated with participation in this study is that some of the questions focus on negative aspects of yourself or negative events in your life, which may result in some discomfort. There is some loss of privacy that your grades and course selections will be accessed by the researchers, but please be assured that these data are used for research purposes only and will be kept entirely confidential.

Please indicate your choice between (a) payment and (b) proof of one hour research participation for course credit by checking ONE of the two spaces below:

I wish to receive \$10 for participation OR
 I wish to use this form for one hour course research participation credit

CONFIDENTIALITY

All information you provide is considered confidential. Because our interest is in the average responses of the entire group of participants, neither you nor your responses will

be identified individually in any way in written reports of this research. Group data only may be published, presented at conferences, used to evaluate programs, or used for secondary data analyses by other researchers. Data collected during this study will be stored in a secure location in Teena Willoughby's office in Plaza 519. Your name will not be kept in the same data file with your questionnaire responses; instead, your name will be kept in a separate file that will be available only to Dr. Teena Willoughby. The student investigators involved in data collection/analyses will only access the unidentifiable data; they will not be able to identify your responses. Note that your responses will NOT be made available to Brock University itself, so there will be no university record of your responses.

VOLUNTARY PARTICIPATION

Participation in this study is voluntary. If you wish, you may decline to answer any questions or participate in any component of the study. Further, you may decide to withdraw from this study at any time without any penalty or loss of benefits to which you are entitled. If at some future date, you decide to withdraw your permission for the researchers to obtain access to your academic records, you may do so by contacting the researchers, without losing your payment or proof of participation. Because we are interested in what happens to students as they go through university, you will be contacted via email (using the email address you provided on this consent form or when you signed up for the study) in the future with opportunities to participate in follow-up studies, but your participation in those studies is completely voluntary.

PUBLICATION OF RESULTS

Results of this study may be published in professional journals and presented at conferences. We will also email you with a summary of the results from this study by August 2009.

CONTACT INFORMATION AND ETHICS CLEARANCE

If you have any questions about this study or require further information, please contact Dr. Teena Willoughby, Faculty Supervisor, using the contact information provided above. This study has been reviewed and received ethics clearance through the Research Ethics Board at Brock University (file 09-118). If you have any comments or concerns about your rights as a research participant, please contact the Research Ethics Office at (905) 688-5550 Ext. 3035, reb@brocku.ca. Thank you for your assistance in this project. Please keep a copy of this form for your records.

Name (printed): _____

Email address: _____

Student number: _____

Signature: _____

Date: _____

Appendix H: Ethics form



Brock University
 Research Ethics Office
 Tel: 905-688-5550 ext. 3035
 Email: reb@brocku.ca

Social Science Research Ethics Board

Certificate of Ethics Clearance for Human Participant Research

DATE: 1/21/2013
 PRINCIPAL INVESTIGATOR: WILLOUGHBY, Teena
 Psychology
 FILE: 12-148 - WILLOUGHBY
 TYPE: Faculty Research STUDENT: Chloe Hamza
 SUPERVISOR: Teena Willoughby
 TITLE: Stressed @ Brock: The lab component

ETHICS CLEARANCE GRANTED

Type of Clearance: NEW Expiry Date: 1/31/2014

The Brock University Social Sciences Research Ethics Board has reviewed the above named research proposal and considers the procedures, as described by the applicant, to conform to the University's ethical standards and the Tri-Council Policy Statement. Clearance granted from 1/21/2013 to 1/31/2014.

The Tri-Council Policy Statement requires that ongoing research be monitored by, at a minimum, an annual report. Should your project extend beyond the expiry date, you are required to submit a Renewal form before 1/31/2014. Continued clearance is contingent on timely submission of reports.

To comply with the Tri-Council Policy Statement, you must also submit a final report upon completion of your project. All report forms can be found on the Research Ethics web page at <http://www.brocku.ca/research/policies-and-forms/research-forms>.

In addition, throughout your research, you must report promptly to the REB:

- a) Changes increasing the risk to the participant(s) and/or affecting significantly the conduct of the study;
- b) All adverse and/or unanticipated experiences or events that may have real or potential unfavourable implications for participants;
- c) New information that may adversely affect the safety of the participants or the conduct of the study;
- d) Any changes in your source of funding or new funding to a previously unfunded project.

We wish you success with your research.

Approved:

 Jan Frijters, Chair
 Social Sciences Research Ethics Board

Note: Brock University is accountable for the research carried out in its own jurisdiction or under its auspices and may refuse certain research even though the REB has found it ethically acceptable.

If research participants are in the care of a health facility, at a school, or other institution or community organization, it is the responsibility of the Principal Investigator to ensure that the ethical guidelines and clearance of those facilities or institutions are obtained and filed with the REB prior to the initiation of research at that site.