J Youth Adolescence (2015) 44:317–330
DOI 10.1007/s10964-014-0107-x

EMPIRICAL RESEARCH

A Longitudinal Examination of the Bidirectional Association Between Sleep Problems and Social Ties at University: The Mediating Role of Emotion Regulation

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Received: 20 December 2013 / Accepted: 21 February 2014 / Published online: 28 February 2014

Abstract Despite the growing body of research linking sleep problems and social ties, research investigating the direction of effects between these two constructs is lacking. Furthermore, there remains a dearth of research examining the mechanisms that may explain the association between sleep problems and social ties within a longitudinal design. The present 3-year longitudinal study addressed two research questions: (1) Is there a bidirectional association between sleep problems and social ties at university? and (2) Does emotion regulation mediate the association between sleep problems and social ties at university? Participants (N = 942, 71.5 % female; $M = 19.01$ years at Time 1, $SD = 0.90$) were university students who completed annual assessments of sleep problems, social ties, and emotion regulation, for three consecutive years. Results of path analysis indicated that the bidirectional association between sleep problems and social ties was statistically significant (controlling for demographics, sleep–wake inconsistency, sleep duration, and alcohol). Analyses of indirect effects indicated that emotion regulation mediated this link, such that better sleep quality (i.e., less sleep problems) led to more effective emotion regulation, which, subsequently, led to more positive social ties. In addition, more positive social ties led to more effective emotion regulation, which, in turn, led to less sleep problems. The findings highlight the critical role that emotional regulation plays in the link between sleep problems and social ties, and emphasize the need for students as well as university administration to pay close attention to both the sleep and social environment of university students.

Keywords Longitudinal · Bidirectional · Sleep · Social ties at university · Emotion regulation

Introduction

In a seminal review article on the importance of interpersonal relationships, Baumeister and Leary (1995) proposed the *belongingness hypothesis*, which states that human beings have an intrinsic need to establish and maintain close social ties. "Social ties", as a construct, generally has been used to denote the extent and/or quality of an individual's interpersonal connectedness with others (Thoits 2011). Developmental researchers have long posited that the formation of social ties with peers is an important developmental life task (Erikson 1968; Havighurst 1972), and that the accomplishment of this life task is believed to positively impact psychosocial adjustment across the lifespan (Roisman et al. 2004). Importantly, findings within the health literature provide empirical support for these theoretical paradigms through studies that have consistently shown that individuals who report more positive social ties tend to live healthier, happier, longer, and more fulfilling lives relative to individuals with poor social ties (Berkman and Syme 1979; Cohen et al. 1997; Eom et al. 2013; House et al. 1988; Puyat 2013). More recently, researchers have begun to explore the role of social ties and its relationship to one particularly important human behavior—sleep.

A growing body of research indicates that individuals' sleep quality is significantly linked to the quality of their

Electronic supplementary material The online version of this article (doi:10.1007/s10964-014-0107-x) contains supplementary material, which is available to authorized users.

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social ties (e.g., Cacioppo et al. 2002). Given the crucial role that sleep quality plays in overall psychosocial adjustment across the lifespan (e.g., Alapin et al. 2000; Ohayon 2002; Segrin and Domschke 2011), it is imperative that researchers specifically examine *how* social ties relate to sleep quality. A first step would be to determine the direction of effects between social ties and sleep quality. A second step is to examine the mechanisms through which social ties and sleep quality are associated by assessing possible mediators of this association. Research addressing the direction of effects, as well as the mechanisms linking social ties and sleep quality, however, is lacking as the majority of studies that have examined this link have been based on concurrent data. Yet, addressing these empirical questions is important particularly for individuals as they transition from adolescence to emerging adulthood.

Within Western cultures, emerging adulthood (approximately 18–25 years) refers to a distinct period of life between adolescence and adulthood, and is generally characterized by higher levels of autonomy relative to adolescence, but fewer responsibilities relative to adulthood (Arnett 2007). For this reason, emerging adults—particularly those at university—may have increased autonomy in setting their sleep–wake patterns (Zimmermann 2011). Thus, sleep characteristics assessed among this population are less likely to be directly influenced by parents and more likely to reflect the individual's own sleep preferences (Orzech et al. 2011). Furthermore, unlike high school where class start times tend to be fixed from day-to-day, university students have some flexibility in selecting class schedules, which may have important implications for sleep–wake patterns and overall sleep quality (Onyper et al. 2012). Moreover, for emerging adults at university, an important aspect of their overall adjustment is the establishment of new friendships at university. In one study based on over 1,800 university students across six Canadian universities, Buote et al. (2007) found that higher friendship quality (based on new friendships established at university) significantly predicted more positive academic, social, personal-emotional, and institutional adjustment. These findings are particularly salient given the proposition that social ties—particularly those with like-others (e.g., those who share similar lived experiences)—are hypothesized to be most fulfilling and effective for overall adjustment through the exchange of *empathetic understanding* (Thoits 1986). Given that emerging adults at university report profound negative changes in their high-school friendships (e.g., become more distant) during the first year of university (Oswald and Clark 2003), and that new friendships at university are strongly predictive of overall university adjustment (Buote et al. 2007), we chose to focus our assessment of social ties on the quality of individuals' social networks specific to the university setting. First, we review the research examining the relationship between sleep problems and social ties. Then we present an overview of the research on sleep problems and social ties and their associations with emotional well-being in order to support our proposed hypothesis that emotion regulation may be one mechanism linking sleep problems and social ties.

Sleep Problems and Social Ties

Poor sleep quality has been significantly associated with lower levels of social support, higher levels of interpersonal conflict, and higher levels of loneliness (Cacioppo et al. 2002; Fortunato and Harsh 2006; Segrin and Domschke 2011). In general, individuals who report more negative social ties tend to report more sleep problems (Aanes et al. 2011; Ailshire and Burgard 2012; Friedman et al. 2005). For example, Howell et al. (2008) found that higher social well being (e.g., social integration) was significantly correlated with better overall sleep quality among university students. Additionally, Cacioppo and colleagues consistently have found a significant concurrent main effect of loneliness on sleep quality, such that lonely individuals tend to report poorer sleep quality relative to non-lonely individuals (e.g., Cacioppo et al. 2002). Despite the rich body of research linking sleep problems and social ties, however, the majority of studies assessing this link have been based on concurrent data. Researchers, therefore, have been unable to specifically examine the direction of effects between these two constructs. In other words, do positive social ties predict better sleep quality or does better sleep quality predict more positive social ties? Alternatively, is the relationship between these two constructs bidirectional?

Some researchers, nonetheless, have inferred a unidirectional association and suggest that negative social ties precede poor sleep—this interpretation is based on the proposition that close, fulfilling interpersonal relationships may provide a context for the experience of positive emotions, which may facilitate better sleep quality (e.g., Aanes et al. 2011; Segrin and Domschke 2011). There is evidence to suggest, however, that the nature of the association between sleep problems and social ties may, in fact, be bidirectional. Specifically, Garde et al. (2012) found a bidirectional association between social ties and sleep quality among a sample of working adults, although this finding was significant only when sleep quality was assessed as an index of difficulties with awakening (e.g., feeling exhausted at awakening), but not when sleep quality was assessed as an index of disturbed sleep (e.g., difficulties falling asleep). In other words, more sleep problems (based on difficulty with awakenings) significantly predicted reports of more problems with work

colleagues and family members, and also, more problems with work colleagues and family members predicted more difficulties with awakenings. Garde et al. (2012) suggested that this bidirectional association could be explained through elevated levels of psychological arousal that hinder cognitive and affective functioning, which are necessary for both sleep quality and interpersonal interactions with others. Importantly, as the authors conducted their study across a 3-day period, the nature of the association between sleep problems and social ties remains to be determined within the context of a long-term longitudinal study. Furthermore, given that Garde et al. (2012) conducted their study with a sample of working adults, it is necessary to examine the nature of the association between social ties and sleep quality among a sample of emerging adults at university whose sleep–wake patterns may be qualitatively different from that of working adults.

Moreover, some authors have assessed the quality of social ties very broadly, based on an aggregate across different domains, including parents, friends, neighbors, and intimate partners (e.g., Aanes et al. 2011; Orzech et al. 2011). Although some studies have specifically focused on isolating the quality of social ties within a specific domain, such as cohabitating intimate partners (Hasler and Troxel 2010), work colleagues (e.g., Nakata et al. 2004), or family members (Ailshire and Burgard 2012), no studies to date have specifically focused on examining the relationship between sleep problems and social ties specific to the university setting. Examining how sleep quality relates to social ties at university in particular, has important implications as social ties specific to the university setting may include relationships with roommates/housemates, who may directly affect an individual's sleep quality (e.g., noisy roommates) (Orzech et al. 2011; Shaikh and Deschamps 2006).

Emotion Regulation as Mediator

Although a significant concurrent link between sleep problems and social ties has been well established within the literature, research examining the mechanisms through which these two constructs are associated is limited (Aanes et al. 2011; Zawadzki et al. 2013). Given that past research has found that emotional well-being is significantly associated with both social ties (e.g., Howell et al. 2008) and sleep problems (e.g., Ohayon 2002), we propose that emotion regulation may be one mechanism linking social ties and sleep quality. Embedded within a functionalist perspective (which posits that emotions are a direct product of the interaction between an individual and his/her environment), emotion regulation refers to the various strategies that an individual employs to monitor, assess, and alter one's reaction to a situation in order to achieve a desired goal (Campos et al. 1994). According to Baglioni et al. (2010), difficulties with emotion regulation can influence the level of an individual's emotional reactivity, which may subsequently give rise to a number internalizing and externalizing problem behaviours. Thus, to support the hypothesis that emotion regulation may play a mediating role in the link between sleep problems, we draw on studies that have assessed various facets of overall emotional well-being, including variables such as depressive symptoms, anxiety, and perceived negative affect. Evidence from both concurrent and longitudinal studies indicates that higher levels of negative affectivity are significantly associated with poor sleep quality (e.g., Jansson-FrÖjmark and Lindblom 2008; Zawadzki et al. 2013). Among individuals diagnosed with a mood disorder (e.g., depression), for example, up to 80 % report insomnia symptoms (Ohayon 2002), and clinical reports of sleep problems have been shown to predict the onset of depression (see Baglioni et al. 2010 for a review). Furthermore, among both university students and working adults, higher levels of neuroticism are significantly associated with more sleep problems (Cheng et al. 2012; Soehner et al. 2007). Notably, models of insomnia have proposed that the nature of the association between emotional well-being and sleep quality may be bidirectional, such that poor emotional well-being would be expected to predict more sleep problems (e.g., difficulty initiating sleep) and, in turn, more sleep problems would be expected to predict poor emotional well-being (e.g., Baglioni et al. 2010). Indeed, longitudinal studies, based on both child and adult samples, have provided some support for this proposed bidirectional hypothesis between sleep quality and negative emotionality (e.g., depression) (Garde et al. 2012; Jansson-FrÖjmark and Lindblom 2008; Kelly and El-Sheikh 2013).

In addition to being significantly associated with sleep quality, emotional well-being also has been linked to social ties (Heinrich and Gullone 2006). In one recent study, Zawadzki et al. (2013) found that loneliness was a significant concurrent predictor of both rumination and anxiety among their sample of university students. Among adult workers, perceived support from supervisor, coworkers, and family members were all significantly correlated with lower depressive symptomatology (Nakata et al. 2004), while lower levels of perceived social support were found to predict higher negative affect among a community sample of adults (Brummett et al. 2006). Furthermore, lower levels of perceived social support have been significantly linked to more depressive symptoms, higher levels of stress (Jackson 2006), higher levels of neuroticism and hostility, and lower levels of positive affect (Pressman et al. 2005). A key aspect of positive social ties, therefore, may be the provision of emotional support (either directly or indirectly), which may facilitate higher levels of

emotional well-being among individuals (e.g., Cohen 2004; Thoits 1986).

The Present Study

Taken together, the findings reviewed above indicate that: (a) social ties are associated with sleep quality, although the specific direction of effects remains unclear; (b) social ties play an important role in emotional well-being; and (c) emotional well-being and sleep quality have been found to be mutually associated. These findings suggest that emotion regulation may be one important mechanism linking social ties and sleep quality. Specifically, more positive social ties may facilitate better emotion regulation, and, subsequently, better emotion regulation may lead to better sleep quality. Moreover, given the evidence of a bidirectional link between emotional well-being and sleep quality, it is left to be determined whether sleep problems might lead to less effective emotion regulation, which, in turn, may negatively affect social ties. These proposed associations have not yet been empirically tested among emerging adults at university within the context of a long-term longitudinal design and thus forms the premise of the present study. The purpose of the present 3-year longitudinal study, therefore, was to address two research questions: (1) Is there a significant bidirectional association between sleep problems and social ties at university? and (2) Does emotion regulation mediate the association between sleep problems and social ties at university?

In addressing the nature of the association between sleep problems and social ties, it also was critical to control for the effects of important third variables that have been shown to be associated with sleep quality and/or social ties. Of note, although we recognize that "sleep problems" is multifaceted and encompasses a variety of sleep characteristics (Kelly and El-Sheikh 2013), for the purposes of the present study, we use the term sleep problems to refer to an individual's subjective perceived quality of his/her sleep experience (independently of sleep duration and sleep–wake irregularity, which we include as covariates—see below). Past studies also have assessed sleep quality based on ratings of problems that include the initiation and maintenance of good sleep (e.g., Buboltz et al. 2001) and include assessments of sleep duration, weekend delay, and/or weekend oversleep as distinct (though related) sleep characteristics (e.g., Lund et al. 2010; Pilcher and Ott 1998; Soehner et al. 2007). Age, gender, and parental education were included as covariates because past studies have reported significant age and gender differences in sleep quality (e.g., Cheng et al. 2012; Tsai and Li 2004), while reports of family income and socioeconomic status have been found to differentiate among sleep characteristics of adolescents (McHale et al. 2011). We also controlled for three important sleep characteristics (i.e., sleep duration, weekend delay, and weekend oversleep), given that past research indicates that shorter sleep duration (Gilbert and Weaver 2010), and more irregular sleep–wake patterns (Monk et al. 1994) have been significantly associated with subjective reports of more sleep problems. In one Canadian sample of university students, socializing with friends was a significant predictor of longer sleep duration during the night, but one additional hour of sleep on a given night was significantly associated with a significant decrease in the likelihood of socializing with friends the next day (Gal-ambos et al. 2009). Additionally, individuals classified as "poor-sleepers" have been found to report consuming significantly more alcohol per day relative to individuals who were classified as "optimal-sleepers" (e.g., Lund et al. 2010) and thus, alcohol use also was included as a covariate in the model.

Methods

Participants

Participants were 942 (71.5 % female) emerging adults who remained enrolled at a mid-sized university in southern Ontario, Canada, across 3 years. Participants ranged in age from 17 to 25 years ($M = 19.01$ years, $SD = 0.90$) at Time 1. The majority (i.e., 88 %) of the sample was domestic-Canadian students, some of whom reported British (19 %), Italian (16.8 %), French (9.5 %), and German (9 %) ethnic backgrounds. Among the international students, the majority reported being from Asia (36.1 %), European Union (15.7 %), the Caribbean (10.2 %) and Africa (10.2 %). Parental education levels (used as a proxy for socioeconomic status) reported by participants 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."

Procedure

We specifically recruited first year university students across a variety of academic disciplines. Potential participants were recruited through visits to on-campus student residences, posters, website postings, as well as classroom announcements and were invited to participate in a longitudinal survey examining factors related to stress, coping, and overall psychosocial functioning across the university years. Surveys were completed annually for 3 years and administered by trained research assistants. As an incentive to participate in the study, students received either course

credit or monetary compensation (CAD $10.00) at Time 1 and monetary compensation at Time 2 (CAD $20.00) and Time 3 (CAD $30.00). Only students who completed the survey at Time 1 were recruited to participate at Time 2 and 3 (through emails, posters, and classroom announcements). The study was approved by the University Ethics board prior to survey administration at all three assessments, and all participants provided informed active consent prior to participation.

Missing Data Analysis

For our sample of 942 emerging adults, missing data occurred because participants did not complete the entire questionnaire at each of the three waves (average missing data = 1.5 %). Missing data occurred also because not all participants completed the survey at all three waves. Out of the original sample that completed the survey at the first assessment, 90.3 % completed at least 2 of the 3 waves (72.8 % completed the survey at all three assessments; 8.5 % completed only the first and second assessments and 9 % completed only the first and third assessments). Results of a MANOVA indicated that participants who completed only the first assessment did not significantly differ from participants who completed at least two out of the three waves on age, parental education, sleep problems, social ties, sleep duration, weekend delay, and weekend oversleep at Time 1 (all p's $> .05$). Individuals who completed only the first wave, however, were more likely to be male ($p = .001$), consumed more alcohol ($p = .028$), and had less effective emotion regulation ($p = .043$) at Time 1, relative to participants who completed at least two out of the three waves. Missing data analysis revealed that the probability of missingness on a given variable was not significantly related to any variable scores (i.e., data were missing at random; Enders 2010). Thus, missing data for the main model were estimated using the full information maximum likelihood (FIML) estimation method. FIML retains cases that have missing data, thus avoiding the biased parameter estimates that can occur with pair-wise or list-wise deletion (Schafer and Graham 2002).

Measures

With the exception of the demographic variables (i.e., age, gender, and parental education) all variables were assessed at three time points, 1 year apart. See Table 1 for range of scores and Cronbach's alpha, if applicable.

Demographics

At the first assessment, we assessed participants' age, gender, and parental education (one item per parent, averaged for participants reporting on both parents, with a scale of *1 = did not finish high school* to *6 = professional degree*, $r = .40$).

Sleep Problems

Sleep problems were assessed using an adapted version of the Insomnia Severity Index (ISI; Morin 1993). Participants were instructed to indicate the extent to which they experience: (1) difficulty falling asleep, (2) difficulty staying asleep, (3) problem waking up too early, and (4) problem staying awake. Response options for these four items ranged from *1 = no problem* to *5 = very severe problems*. The fifth item asked: How satisfied are you with your sleep pattern? Response options ranged from *1 = very satisfied* to *5 = very dissatisfied*. The last item asked: To what extent do you think your sleep patterns interfere with your daily functioning (daytime fatigue, ability to function at school or daily tasks, concentration, memory, mood, etc.)? Response options ranged from *1 = rarely interferes* to *4 = very often interferes*. Responses to these six items were coded such that higher summed scores indicate more sleep problems (i.e., poorer sleep quality). High internal consistency coefficients for the ISI have been reported in past studies based on university students in the US (Cronbach's $\alpha = 0.85$; see Cukrowicz et al. 2006), a community and clinical sample of older adults in Canada (Cronbach's $\alpha = 0.90$ and 0.91, respectively; see Morin et al. 2011), as well as a sample of adolescents in China (see Chung et al. 2011). In terms of convergent validity, the ISI has been shown to be significantly associated with both objective measures of sleep efficiency obtained from polysomnography and sleep diary measures in older adults (Morin et al. 2011), as well as measures of depression and disturbed dreams and nightmares among university students (Cukrowicz et al. 2006).

Social Ties

Three items from the social adjustment subscale of the Student Adaptation to College Questionnaire (SACQ; Baker and Siryk 1989) were used to assess social ties at university: (1) I am meeting people and making friends at university; (2) I have several close social ties at university and (3) I am satisfied with how much I am participating in social activities at university. Responses ranged from *1 = not at all like me* to *5 = completely like me*. Results of a principal components factor analysis with varimax rotation indicated that the three items hung together as one factor, with factor loadings ranging from 0.71 to 0.79 at Time 1, 0.70 to 0.81 at Time 2, and 0.76 to 0.82 at Time 3. Higher scores indicate more positive social ties at university.

Table 1 Descriptive statistics for all study variables

Variable	*M* (*SD*)	Range	Number of items	Cronbach's α
Age	19.01 (0.90)	17.17–25.51	1	n/a
Gender	71.5 % female	n/a	1	n/a
Parental education	3.68 (1.29)	1–6	2	n/a
Sleep problems1	13.82 (4.26)	6–29	6	0.76
Sleep problems2	14.16 (4.20)	6–29	6	0.76
Sleep problems3	13.92 (4.42)	6–29	6	0.79
Social ties1	3.23 (0.91)	1–5	3	0.68
Social ties2	3.20 (0.93)	1–5	3	0.73
Social ties3	3.24 (0.97)	1–5	3	0.76
Difficulties with emotion regulation1	2.76 (0.76)	1–5	6	0.73
Difficulties with emotion regulation2	2.84 (0.76)	1–5	6	0.74
Difficulties with emotion regulation3	2.84 (0.76)	1–5	6	0.76
Emotion reactivity1	2.18 (0.84)	1–5	13	0.93
Emotion reactivity2	2.21 (0.82)	1–5	13	0.93
Emotion reactivity3	2.31 (0.86)	1–5	13	0.94
Sleep duration1	8.60 (1.22)	4–15	4	n/a
Sleep duration2	8.31 (1.19)	4–13	4	n/a
Sleep duration3	8.27 (1.17)	4–12	4	n/a
Weekend delay1	1.56 (1.14)	−7 to 6	2	n/a
Weekend delay2	1.57 (1.18)	−4 to 8	2	n/a
Weekend delay3	1.43 (1.16)	−3 to 6	2	n/a
Weekend oversleep1	2.16 (1.62)	−3 to 8	2	n/a
Weekend oversleep2	2.33 (1.61)	−4 to 9	2	n/a
Weekend oversleep3	2.03 (1.52)	−4 to 8	2	n/a
Alcohol1				
Number	3.82 (1.38)	1–6	1	n/a
Frequency	3.69 (1.60)	1–8	1	n/a
Alcohol2				
Number	3.95 (1.25)	1–6	1	n/a
Frequency	3.64 (1.43)	1–8	1	n/a
Alcohol3				
Number	3.81 (1.23)	1–6	1	n/a
Frequency	3.44 (1.37)	1–8	1	n/a

Numbers 1, 2, and 3 represent Time 1, Time 2, and Time 3, respectively

Emotion Regulation

Emotion regulation was assessed based on a composite of two scales, namely: (1) *difficulties with emotion regulation*: We used six items adapted from the Difficulties with Emotion Regulation Scale (DERS; Gratz and Roemer 2004). Participants were asked to rate the frequency with which six different emotion regulation strategies was applicable to them (e.g., "When I am upset or stressed, I have difficulty thinking about anything else"). Responses ranged from *1 = Almost never* to *5 = Almost always*. Higher scores indicate more difficulties with emotion regulation. (2) *Emotion reactivity*: We assessed emotion reactivity using 13 items from the Emotional Reactivity Scale (ERS; Nock et al. 2008). Participants were asked to rate the extent to which 13 statements reflected their emotional reactions (e.g., "When I am angry/upset, it takes me much longer than most people to calm down"). Responses ranged from *1 = Not at all like me* to *5 = Completely like me*. Higher scores indicate greater negative emotional reactivity. Scores on these two scales were averaged to form a composite of emotion regulation.

Sleep Duration

Sleep duration was calculated from participants' bed times ("What time do you normally fall asleep?") and wake times ("What time do you normally wake up?"), averaged

across the week and weekend. Higher scores indicate longer sleep duration (in hours).

Weekend Delay

We assessed weekend delay by calculating the difference in average bed times between the week and the weekend, where higher scores indicate more irregular bed times across the week and weekend.

Weekend oversleep

We assessed weekend oversleep by calculating the difference in average wake times between the week and the weekend, with higher scores indicating more irregular wake times across the week and weekend.

The assessment of weekend delay and weekend oversleep as discrepancies and bed times and wake times, respectively, have been used in past studies to index sleep–wake irregularity (e.g., see Lund et al. 2010; Soehner et al. 2007; Wolfson and Carskadon 1998).

Alcohol

We assessed both the frequency and amount of alcohol consumed: (1) *frequency*: "How often do you go drinking or have a drink"? Responses ranged from 1 = *Never* to 8 = *Everyday*. (2) *Amount*: "On average, when you are drinking alcohol, about how many drinks do you have"? Responses ranged from 1 = *less than 1 drink* to 6 = *over 10 drinks*. Scores across the two items were standardized and averaged such that higher scores indicate higher alcohol consumption.

Plan of Analyses

The main statistical analyses were conducted using path analysis in AMOS version 20.0. Criteria for model fit were based on the comparative fit index (CFI) and the root mean squared error of approximation (RMSEA), such that a CFI value greater than .95 and a RMSEA value of less than .06 (simultaneously) indicated good fit (Hu and Bentler 1999). Our analyses were based on two separate path models. The first model was used to assess the bidirectional association between sleep problems and social ties at university. This model was comprised of six variables: (i.e., sleep problems and social ties assessed at three time points, as well as four control variables—sleep duration, weekend delay, weekend oversleep, and alcohol—also assessed at three time points).

The second model, based on the Bootstrap method of indirect effects, was used to test the mediating role of emotion regulation. In bootstrapping, cases from the original dataset are selected randomly (with replacement) in order to generate additional data sets, usually with the same number of cases as the original data set. This is done multiple times (e.g., 2000) in order to resemble the selection of multiple random samples from a given population (Kline 2011). Using the bootstrapping approach, we examined whether there was a significant indirect path from social ties to sleep problems through emotion regulation, and also, whether there was a significant indirect path from sleep problems to social ties through emotion regulation. Thus, this second model was comprised of three variables: sleep problems, emotion regulation, and social ties.

For both models, we included lag-1 cross-lag paths as well as lag-1 and lag-2 autoregressive paths for all study variables that were assessed at the three time points. We also accounted for concurrent associations among the study variables within a wave by specifying correlations between the error terms. Correlations also were specified between Time 1 covariates (age, gender, and parental education) and all study variables assessed at Time 1. Finally, for both models, paths were estimated from age, gender, and parental education to each study variable assessed at Time 2 and Time 3.

Results

Table 1 shows descriptive statistics (e.g., means and standard deviations) for all study variables. Across the 3 years, participants reported average sleep duration scores ranging from 8 h and 16 min in Year 3 to 8 h and 36 min in Year 1. The means for sleep problems across the 3 years were generally low (ranging from 13.82 in Year 1 to 14.16 in Year 2 (on a 6–29 scale, with higher scores indicating more sleep problems or poorer sleep quality). Finally, stability paths for sleep problems were relatively highly stable over time (standardized beta coefficients were .56 for Time 1 to Time 2 and .47 for Time 2 to Time 3).

Research Question 1: Is There a Significant Bidirectional Association Between Sleep Problems and Social Ties at University?

In order to assess model fit for the first model, we compared a cross-lagged model (see plan of analyses section above) where the paths were constrained across the three waves, [χ^2 (60) = 71.07, p = .155; RMSEA = .014, 95 % CI (.000, .025), CFI = .998], to a cross-lagged model where paths were unconstrained (i.e., free to vary) over time, [χ^2 (30) = 32.65, p = .338, RMSEA = .010, 95 % CI (.000, .027), CFI = .999]. Results of a Chi square difference test of relative fit indicated that the unconstrained model did not provide a significantly better fit to the data

Table 2 Beta weights and standard errors for all Time 1 to Time 2 cross-lagged and stability paths

Path	*B*	*β*	*SE*	*p*
Sleep problems1 → sleep problems2	.553	.555	.031	.000
Sleep problems1 → sleep duration2	−.023	−.084	.007	.000
Sleep problems1 → weekend delay2	−.003	−.010	.007	.683
Sleep problems1 → weekend oversleep2	.021	.056	.010	.032
Sleep problems1 → social ties2	−.012	−.053	.005	.026
Sleep problems1 → alcohol2	.003	.015	.004	.380
Social ties1 → social ties2	.553	.522	.032	.000
Social ties1 → sleep problems2	−.279	−.060	.101	.006
Social ties1 → sleep duration2	.042	.032	.030	.169
Social ties1 → weekend delay2	−.017	−.013	.031	.589
Social ties1 → weekend oversleep2	.016	.009	.044	.716
Social ties1 → alcohol2	−.008	−.007	.016	.634
Sleep duration1 → sleep duration2	.422	.433	.032	.000
Sleep duration1 → sleep problems2	−.073	−.021	.077	.342
Sleep duration1 → weekend delay2	−.015	−.05	.024	.538
Sleep duration1 → weekend oversleep2	.030	.023	.033	.361
Sleep duration1 → social ties2	−.019	−.025	.018	.278
Sleep duration → alcohol2	.002	.002	.012	.890
Weekend delay1 → weekend delay2	.327	.311	.036	.000
Weekend delay1 → sleep problems2	−.054	.014	.086	.531
Weekend delay1 → sleep duration2	.018	.017	.026	.479
Weekend delay1 → weekend oversleep2	.077	.055	.037	.037
Weekend delay1 → social ties2	−.024	−.029	.020	.221
Weekend delay → alcohol2	.014	.017	.013	.309
Weekend oversleep1 → weekend oversleep2	.304	.306	.035	.000
Weekend oversleep1 → sleep problems2	.032	.012	.058	.583
Weekend oversleep1 → sleep duration2	.028	.038	.017	.113
Weekend oversleep1 → weekend delay2	−.032	−.043	.018	.076
Weekend oversleep1 → social ties2	.014	.025	.013	.278
Weekend oversleep1 → alcohol2	−.016	−.028	.009	.078
Alcohol1 → alcohol2	.743	.752	.023	.000
Alcohol1 → sleep problems2	.155	.034	.107	.146
Alcohol1 → sleep duration2	.039	.031	.032	.219
Alcohol1 → weekend delay2	.321	.249	.033	.000
Alcohol1 → weekend oversleep2	.016	.009	.046	.728
Alcohol1 → social ties2	.024	.024	.024	.317

Higher scores indicate: more sleep problems, better social ties, longer sleep duration, longer weekend delay and oversleep, and more alcohol consumption. Numbers 1 and 2 indicate Time 1 and Time 2, respectively. Note that because paths were invariant across time, the pattern of results is the same from Time 2 to Time 3 (not shown)

B unstandardized beta weights, *β* standardized beta weights, *SE* standard error

compared to the constrained model, χ^2_{diff} (30) = 38.42, $p = > .05$; suggesting that the pattern of associations among the variables was invariant across the three waves. Thus, our analysis of this research question was based on the constrained model as this was the more parsimonious model. As the pattern of associations was invariant across time, the regression coefficients presented below (as well as the coefficients presented in Table 2) refer only to results from Time 1 to Time 2 (i.e., the pattern of results are the same from Time 2 to Time 3). As shown in Table 2, results of path analysis indicated that there was a significant bidirectional association between sleep problems and social ties at university, such that more sleep problems significantly predicted less positive social ties over time, $\beta = -.053$, $SE = .005$, $p = .026$, and, in turn, less positive social ties at university significantly predicted more sleep problems over time, $\beta = -.060$, $SE = .101$, $p = .006$ (see Fig. 1).

Research Question 2: Does Emotion Regulation Mediate the Association Between Sleep Problems and Social Ties at University?

To assess the potential mediating role of emotion regulation between social ties and sleep problems, we tested two separate mediation models (based on a test of indirect

effects). Specifically, we assessed whether: (1) social ties at university would predict sleep problems through emotion regulation and (2) sleep problems would predict social ties at university through emotion regulation. Bootstrap method analyses for indirect effects indicated a significant indirect path from social ties (at Time 1) to sleep problems (at Time 3) through emotion regulation (at Time 2), $\beta = -.007$, $SE = .003$, $p = .002$, 95 % CI [−.015, −.002], and also a significant indirect path from sleep problems (at Time 1) to social ties (at Time 3) through emotion regulation (at Time 2), $\beta = -.005$, $SE = .003$, $p = .017$, 95 % CI [−.012, −.001].

Covariates

In terms of the Time 1 covariates (age, gender, and parental education), results of the cross-lagged path model indicated that being younger, male status, and reports of higher parental education predicted greater alcohol use over time, whereas being younger and female status were significant predictors of more positive social ties over time. The cross-lagged path model also included covariates (sleep duration, weekend delay, weekend oversleep, and alcohol), that were controlled for at each of the three assessments. As can be seen from Fig. 1, results indicated that greater alcohol use predicted longer weekend delays, and longer weekend delays predicted longer weekend oversleep. More sleep problems predicted both shorter sleep duration and longer weekend oversleep. None of these covariates predicted either social ties or sleep problems.

Discussion

Although past studies indicate a significant link between sleep problems and social ties, there remains a dearth of studies examining the direction of effects between these two constructs. Furthermore, as the majority of studies have been based on concurrent data, researchers have been unable to assess possible mechanisms (i.e., mediators) that may explain the association between sleep problems and social ties within a longitudinal design. The present 3-year longitudinal study was conducted to address these two important gaps in the literature. Results showed a significant bidirectional association between sleep problems and social ties, such that more sleep problems predicted less positive social ties at university, and consequently, less positive social ties at university predicted more sleep problems. Importantly, tests of indirect effects provide evidence for the critical role that emotion regulation plays in explaining this bidirectional association between sleep problems and social ties.

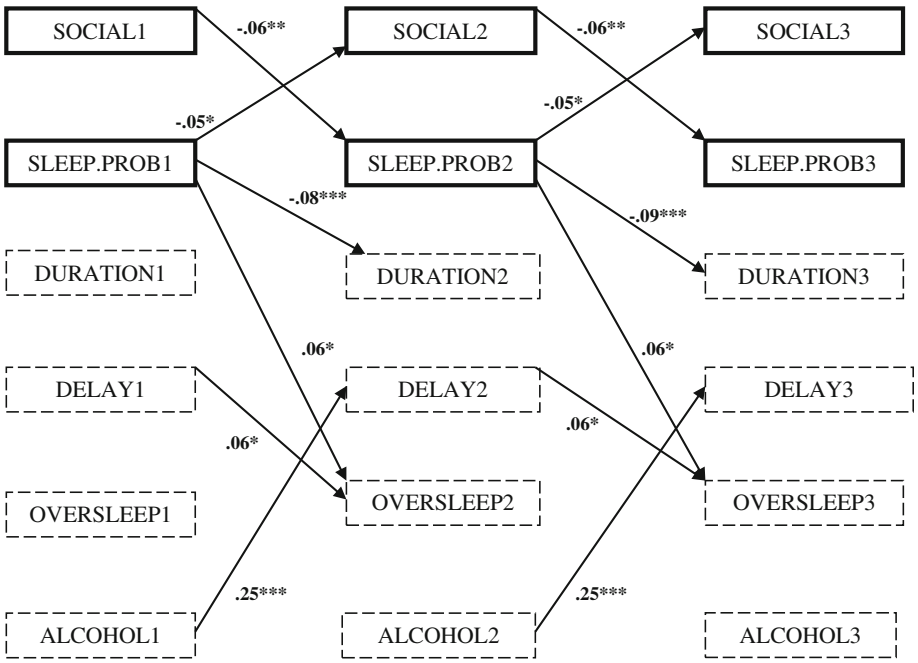

Fig. 1 Significant paths. *Note* $*p < .05$, $**p < .01$, $***p < .001$. *Values* indicate standardized beta weights (unstandardized beta weights along with standard errors are presented in Table 2). *SOCIAL* social ties at university, *SLEEP.PROB* sleep problems, *DURATION* sleep duration, *DELAY* weekend delay, *OVERSLEEP* weekend oversleep, *ALCOHOL* alcohol use. *Higher scores* indicate: more positive social ties, more sleep problems, longer sleep duration, longer weekend delay, longer weekend oversleep, and higher alcohol consumption. *Numbers 1*, *2*, and *3* indicate Time 1, Time 2, and Time 3, respectively. Covariates are indicated by *dashed rectangles*. Not shown are the three Time 1 covariates (age, gender, and parental education), results for which may be requested by the first author

Our results showed that, on the one hand, more positive social ties at university led to more effective emotion regulation, which, subsequently, led to better sleep quality; and also that more sleep problems led to less effective emotion regulation, which, in turn, led to less positive social ties at university. Cohen consistently has highlighted the important role that positive social ties play in overall emotional functioning (see Cohen 2004). Individuals who form part of our social networks may facilitate effective emotion regulation both directly (e.g., by providing specific solutions to a problem) or indirectly (e.g., bolstering the individual's psychological and cognitive resources so that they are better equipped to deal with stressors) (Buote et al. 2007; Cohen 2004; Thoits 1986). Notably, our assessment of social ties was specific to the university setting. In particular, our measure of social ties was based on participants' subjective reports of the degree of their involvement in social activities at university, as well as the establishment of new friendships with university peers. This approach serves as an important extension of the literature, as past studies examining social ties and sleep quality have assessed social ties as either social support or relationship quality in general or lumped together across various domains such as friend/family member/partner (e.g., Aanes et al. 2011), as opposed to assessing social ties specifically at university.

For students, our findings suggest that participating in university activities and establishing social ties at university may be beneficial for sleep quality through the facilitation of effective emotion regulation. Importantly, Thoits (1986) states that support from like-others may prove to be particularly effective in helping individuals cope with stressors through the exchange of empathetic understanding (Thoits 1986). According to Thoits (1986), these like-others include other individuals who share similar demographic backgrounds and have shared lived experiences. Thus, it follows that university peers who also are transitioning through university and who are experiencing similar challenges (e.g., living away from home, adjusting to class schedules and other academic demands, establishing social networks), may play an instrumental role in students' emotion regulation strategies. Therefore, it may be worthwhile for university housing/residence staff to design programs that facilitate high levels of group interaction so as to increase opportunities for all students to create meaningful social ties (Shaikh and Deschamps 2006).

Among our sample of emerging adults at university, more difficulties with emotion regulation predicted more sleep problems. This finding was not surprising as past research supports a significant link between emotion regulation and sleep quality (Cheng et al. 2012; Ohayon 2002; Soehner et al. 2007). Theoretical models of insomnia propose that poor emotion regulation predict more sleep problems through heightened cortical, cognitive, and physiological arousal (Baglioni et al. 2010; Espie 2002; Perlis et al. 1997). In one study, for example, Harvey (2000) found that reports of cognitive intrusions (e.g., worries and concerns) were significantly more prevalent among individuals with clinical levels of insomnia compared to controls. Given that a state of de-arousal is optimal for the initiation and maintenance of good sleep quality (Espie 2002), it follows that such heightened arousal would result in increased sleep problems among individuals (Baglioni et al. 2010).

Moreover, in keeping with past studies (e.g., Tavernier and Willoughby 2013), results of the present study indicated a significant bidirectional association between sleep problems and emotional well-being such that poor emotion regulation predicted more sleep problems, and also, sleep problems predicted poor emotion regulation over time. Our findings extend past research by demonstrating that poor sleep quality may hinder an individual's ability to establish positive social ties, through compromised emotion regulation skills. Individuals with poor emotion regulation may appear to peers as hostile and neurotic—traits that have been associated with greater negative affect and lower positive affect (Brissette and Cohen 2002), and thus may not be conducive to participation in group activities. Indeed, findings from qualitative interviews with university students indicate that students perceive poor sleep as having a negative impact on their mood, which, consequently, may make it more difficult to establish and maintain social ties with peers (Orzech et al. 2011).

In addition to the significant findings relating to the bidirectional association between sleep problems and social ties, as well as the mediating effect of emotion regulation, the present study also assessed important covariates (sleep duration, weekend delay, weekend oversleep, and alcohol use) that warrant some discussion. The only significant finding relating to sleep duration was that more sleep problems predicted shorter sleep duration over time. As an extension of past studies that have found a significant concurrent association between sleep problems and sleep duration but have been unable to establish the direction of effects (e.g., Gilbert and Weaver 2010; Liu and Zhou 2002), findings from the present study provide support for a unidirectional association between the two constructs. The finding of a significant predictive effect from sleep problems to sleep duration was not surprising, given that our measure of sleep problems included problems such as difficulty initiating and maintaining sleep, which would be expected to negatively interfere with an individual's total time spent asleep. It is important to note that, although poor sleep quality led to shorter sleep duration over time, sleep duration did not predict sleep problems. This finding suggests that, whereas shortened sleep duration may be one

negative consequence of poor sleep quality, shortened sleep duration did not lead to poorer sleep quality over time.

Notably, participants in the present study reported average sleep duration of more than 8 h per night, which is comparable to reports of estimated sleep duration in one US sample of university students (i.e., 8 h, 2 min during the week and 8 h, 27 min on the weekend; Buboltz et al. 2001), but higher than findings from other studies where reports of sleep duration ranged from 6 h, 42 min to 7 h, 12 min per night, also among university students (e.g., Ban and Lee 2001; Galambos et al. 2012; Gilbert and Weaver 2010). These discrepant findings in sleep duration across studies may be due to methodological differences in how sleep duration was assessed. For example, sleep duration was significantly higher (i.e., 8 h, 2 min) when calculated from participants' reported sleep–wake times, relative to when participants were directly asked to estimate their daily sleep duration (i.e., 6 h, 55 min) (Buboltz et al. 2001).

Moreover, in the present study, both poor sleep quality, as well as longer weekend delay, predicted longer weekend oversleep, suggesting that sleep problems, as well as discrepancies in bedtimes across the week, interfere with individuals' ability to maintain consistent wake times across the week. Indeed, past research has found that individuals who experience poor sleep quality and adopt irregular bed times may compensate by sleeping in for longer periods of time on the weekends (Jefferson et al. 2005). Additionally, our findings indicate that greater alcohol use predicted more inconsistent bed times across the week (i.e., longer weekend delays). This finding was not surprising given that alcohol use is typically considered a night time social activity in North American society (Negriff et al. 2011), particularly among university students (Galambos et al. 2011), and thus would be expected to interfere with individuals' ability to maintain consistent bed times across the week and weekend. No other predictive effects were found for alcohol use in the present study. Although Lund et al. (2010) found a significant mean difference on the number of alcoholic drinks consumed between university students reporting "good" versus "poor" sleep quality, follow-up regression analyses indicated that alcohol use was not a significant predictor of sleep quality among their sample of university students. The non-significant association between alcohol use and sleep problems also has been confirmed in other studies (e.g., Galambos et al. 2011; Orzech et al. 2011), suggesting that alcohol use may not lead to changes in university students' subjective sleep problems over time. Of note, sleep quality remained highly stable over time, which is consistent with past studies that have employed multiple assessments of sleep quality based on both child (e.g., Kelly and El-Sheikh 2013) and adult samples (e.g., Buysse et al. 2008). In the present study, the stability of sleep problems across the first 3 years of university may be due to stable environmental factors, such as poor sleep hygiene (Buboltz et al. 2002), as well as individual differences in physiological functioning, such as susceptibility to heightened autonomic arousal, which may sustain sleep problems (Espie 2002).

Despite the present study's contribution to the literature, the findings must be interpreted against the study's limitations. First, although we recruited a representative sample of students (e.g., across various academic disciplines, and living situation), participants were all drawn from one university and thus findings from the current study may not be generalizable to other populations including emerging adults who are not enrolled at university. Second, by focusing on the role of social ties specific to the university setting, we excluded social ties from other domains including family members and friends outside of university. Our decision, however, to isolate the role of social ties specific to the university setting was based on Thoits' (1986) proposition that social support from like others should prove to be most effective for facilitating optimal emotional regulation because individuals who have shared lived experiences (as in the case of university peers who also are transitioning across university) are able to provide empathetic understanding, which is a key component of social support. Importantly, given that our measure of social ties was based on students' satisfaction with their participation in university activities, as well as their perceived satisfaction with the establishment of new friendships and close social ties at university, an important extension of the present study would be to specifically assess the types of social support received (e.g., emotional), as well as the actual quality of these social ties. Future studies that specifically assess how the quality of students' relational functioning (within the context of their university friendships) is associated with their emotional functioning and sleep characteristics will shed further light on the actual mechanisms linking social ties and emotion regulation. Third, participants in the present study generally reported few sleep problems and average sleep duration of greater than 8 h per night. Findings, therefore, may not be generalizable to clinical samples. In fact, an important extension of the current study would be to assess the associations found in the present study with a sample of individuals with clinical levels of sleep problems and chronic sleep deprivation, as well as individuals with clinical levels of internalizing problems, such as depression and/or anxiety. For example, the strength of the associations among social ties, emotion regulation, and sleep problems may be stronger among individuals who are clinically sleep deprived, relative to individuals who report adequate sleep duration. Fourth, as our assessment of sleep problems was based on participants'

subjective reports, it may be worthwhile to explore the associations found in the present study based on objective assessments of sleep problems (e.g., actigraph recordings). Lastly, our assessment of social ties, which also was based on participants' subjective self-reports, could have been further validated against reports of social ties from peers. Still, we believe that an individual's own subjective assessment of their social ties at university would perhaps provide the most valid assessment. We also note that the effect sizes found in the present study would be considered "small" relative to traditional standards (e.g., Cohen 1992). However, we highlight the fact that the use of such a conservative cross-lagged model was a strength of the present study (i.e., controlling for previous scores on the outcome variables as well as other predictors and covariates; accounting for associations among all study variables within a wave; and controlling for Time 1 covariates of age, gender, and parental education).

Conclusion

Taken together, our results emphasize the importance of social ties for sleep quality, and, in turn, the importance of sleep quality for social ties. Results of the present study also highlight the crucial role that emotion regulation plays in explaining the bidirectional link between sleep problems and social ties at university. Positive social ties predicted less sleep problems through effective emotion regulation and, in turn, less sleep problems predicted more positive social ties through effective emotion regulation. Our findings, therefore, suggest that if both students and university administration become more vigilant about adopting a balanced approach in fostering opportunities for the establishment of positive social ties while also maintaining an environment that is conducive to good quality sleep, students may be better equipped to effectively cope with the stressors that are inevitably part of their university experience.

Acknowledgments The second author acknowledges funding received from the Social Sciences and Humanities Research Council of Canada. The authors wish to thank Ann Farrell for assistance with coding sleep variables.

Author Contributions R.T. conceived of the study, designed and performed the statistical analyses, and drafted the manuscript; T.W. participated in drafting of the manuscript, as well as collected the data. Both authors read and approved the final manuscript.

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