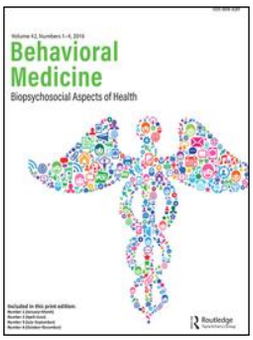

Behavioral Medicine

ISSN: 0896-4289 (Print) 1940-4026 (Online) Journal homepage: https://www.tandfonline.com/loi/vbmd20

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To cite this article: Angela F. Lukowski, Lauren Eales & Dmitry Tsukerman (2018): Sleep Hygiene Mediates, but Does Not Moderate, Associations Between Temperament and Sleep Quality in University Students, Behavioral Medicine, DOI: 10.1080/08964289.2018.1509052

To link to this article: https://doi.org/10.1080/08964289.2018.1509052

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https://doi.org/10.1080/08964289.2018.1509052

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Sleep Hygiene Mediates, but Does Not Moderate, Associations Between Temperament and Sleep Quality in University Students

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ABSTRACT

Although there are theoretical reasons to expect associations among temperament, sleep hygiene behaviors (SHB), and global sleep quality (GSQ), these relations have not yet been examined despite their potential impact on undergraduate student well-being. The present study was conducted to (1) examine relations between temperament and GSQ in university students broadly recruited, (2) document associations between SHB and temperament in this sample, and (3) to determine whether associations among temperament, SHB, and GSQ were best explained by mediation or moderation models. One hundred fifty-two university students completed questionnaires that inquired about temperament, SHB, and GSQ. Correlations revealed that poorer SHB and GSQ were associated reduced effortful control; poorer SHB was also associated with increased negative affect (SHB and GSQ were unrelated to extraversion and orienting sensitivity). Mediation models assessing relations amongst temperament, SHB, and GSQ indicated that negative affect and effortful control may predispose university students to engage in fewer SHB, negatively impacting GSQ; variability in SHB did not moderate the impact of temperament on GSQ. Additional research is needed to confirm and extend these findings, with the ultimate goal of improving undergraduate GSQ (a) by reducing negative affect and increasing effortful control or (b) by improving SHB that are uniquely associated with these temperament profiles.

KEYWORDS

sleep quality; sleep hygiene; temperament; university students

Introduction

University students commonly experience sleep problems[1] that may impair academic functioning[2,3] and mental health.[4,5] As such, understanding correlates of poor quality sleep in university students may lead to the identification of ways in which to improve both nighttime sleep habits and daytime functioning. Previous research suggests that two potentially influential factors may be temperament and sleep hygiene behaviors (SHB). Temperament has been associated with sleep from infancy to young adulthood, with results generally indicating that sleep problems are related to increased negative affect and sensitivity to environmental stimuli as well as reduced effortful control. Research also indicates that sleep problems co-occur with poor SHB, or engaging in practices before sleep that may diminish nighttime sleep quality (such as ingesting caffeine before bed, going to bed at different times each night, and engaging in important or cognitively-demanding work before sleep[6]). Although there are theoretical reasons to expect associations among temperament, SHB, and global sleep quality (GSQ), these relations have not yet been examined despite their potential impact on undergraduate student well-being. The present study was conducted to (1) examine relations between temperament and GSQ in university students broadly recruited, (2) document associations between SHB and temperament in this sample, and (3) identify the pathways by which temperament, SHB, and GSQ are related.

Temperament is conceptualized as stable individual differences in reactivity and regulation that are biologically based and further refined through experience in the broader cultural milieu.[7] Whereas reactivity refers to the physiological responses of bodily systems to environmental stimuli, regulation reflects the ability to moderate or control these responses. Temperament is viewed as a subcomponent of or precursor to adult personality,[8] with various dimensions of adult temperament demonstrating significant similarity to components

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of the Big Five model of personality.[9] In the Adult Temperament Questionnaire, for example, the four temperament dimensions include effortful control (focusing on elements of executive functioning), extraversion (focusing on reactions to potentially positive situations), negative affect (focusing on reactions to potentially aversive situations), and orienting sensitivity (focusing on sensitivity to changes in perception, cognition, and affect).[9] Associations between sleep and temperament have been most widely and consistently documented in the infancy literature. In early research on sleep-temperament associations, more frequent night waking was associated with an increased sensitivity to low-intensity environmental stimuli.[10] More recent research has confirmed associations between infant night waking and perceptual sensitivity[11,12] and has revealed additional relations between infant sleep habits and temperament (see references 13–24). Broadly speaking, the findings amassed to date indicate that more frequent infant night waking is associated with features of a difficult temperament profile (characterized by increased negative affect, reduced rhythmicity and adaptability, and heightened distractibility), whereas easier temperament profiles have been associated with greater nighttime sleep duration and fewer night wakings.

A number of studies have also documented relations between sleep and temperament in older children and adolescents. For example, aspects of difficult temperament profiles (including slower adaptation, intense responses, and negative mood) were negatively related to total sleep duration in preschoolers.[25] Reports of sleep-temperament associations in elementary schoolers indicate that sleep problems are associated with heightened negative affect and an increased intensity of emotional responses.[26] In more recent work with school-aged children, increased emotional intensity was associated with shorter nighttime sleep duration and increased activity at night.[27] When considering adolescents, sleep problems have been associated with aspects of temperament including increased negative affect, reduced effortful control, and increased affiliativeness or sociability; sleep problems were not associated with extraversion or surgency.[28]

Whereas there is a considerable body of work examining sleep-temperament associations over the first two decades of life, studies demonstrating comparable relations in university students and older adults is surprisingly limited. The one relevant study that has been conducted to date with university students examined relations between temperament and sleep quality in participants with generally healthy sleep habits (i.e., students who obtained at least 6 hours of sleep per night and went to bed before 2:00 am at least 3 nights per week, among other characteristics[29]). Consistent with previous research, poorer GSQ in this sample was associated with increased negative affect, reduced effortful control, and increased orienting sensitivity; significant relations were not found between GSQ and extraversion. Somewhat intriguingly, significant associations between poorer GSQ and increased orienting sensitivity have been obtained from infancy to young adulthood,[10] although the association reported in infancy focused on increased *perceptual sensitivity*, whereas the findings with adults primarily resulted from increased *associative sensitivity*, or an increase in "… the occurrence of spontaneous cognitions unassociated with the environment" (see p. 226 of reference 29).

Research has also revealed reliable relations between certain aspects of temperament and SHB, particularly when considering the temperament dimension of effortful control. This aspect of temperament has been associated with aspects of executive functioning, or a constellation of cognitive processes critical for the completion of higher-order goal-directed behaviors (including inhibitory control, set-shifting, working memory, and others[30]). Previous research indicates that inhibitory control, one particular aspect of executive functioning, is associated with health behaviors. In a cross-sectional study, poorer inhibitory control on a Stroop task was related to fewer health protective behaviors and increased health risk behaviors.[31] Other research has made explicit longitudinal connections between inhibitory control and SHB, such that the ability to inhibit responding in a Stroop task was the strongest predictor of future SHB even after accounting for past SHB.[32]

SHB has also been associated with GSQ in healthy adults without diagnosed sleep problems. In American college students, SHB such as worrying about falling asleep, hearing noises during the night, and experiencing thirst before sleep predicted poorer GSQ.[33] Similarly, poorer SHB was associated with reduced GSQ in university students from Hong Kong.[34] Finally, work conducted with Taiwanese university students found that the frequency of irregular bedtimes, one element of SHB, was associated with poorer GSQ.[35] As such, findings consistently demonstrate that good SHB is related to better quality sleep in university students. Despite these associations, however, poor SHB is not believed to be a primary cause of sleep problems, particularly insomnia. Instead, poor SHB is thought to be a secondary contributor, such that affected individuals may alter their SHB in an effort to improve their sleep problems (for example,

by spending more time in bed reading or watching television until they become tired).[36]

Because SHB is not believed to be a primary contributor to poor GSQ, research is needed to identify other possible antecedents. Variability in temperament is one potential candidate. The 3 P model proposed by Spielman and colleagues[37] supports the notion that variability in temperament may predispose individuals to sleep problems. According to his framework, as reviewed in reference,38 sleep problems result from interactions between predisposing and precipitating factors, and are maintained (i.e., become chronic) due to the influence of perpetuating factors. Predisposing factors include trait-based biological, psychological, or social factors; as such, variability in temperament is likely best conceptualized in this manner. Precipitating factors are commonly characterized as life stressors, such as physical or mental illnesses. Behaviors that individuals use to compensate for or counteract against their sleep problems are identified as perpetuating factors. According to the 3 P model, temperamental variability may make individuals more vulnerable or resistant to the influence of various precipitating factors. For example, low negative affect might serve to buffer or protect against the impact of stressful life events, whereas high negative affect might predispose individuals to more intense reactions to challenging situations. An additional possibility is that reactivity to stressful life events may be moderated by SHB. Whereas variability in SHB may be unassociated with reactivity in individuals low on negative affect, individuals high on negative affect may be more or less reactive to stressful situations in relation to SHB. That is, individuals high on negative affect may react more intensely to stressful life events when paired with poorer SHB, negatively impacting GSQ; conversely, those high on negative affect may react minimally or moderately to stressful life events when paired with better SHB, with little negative effect on GSQ. In these scenarios, the relationship between SHB and GSQ is presumed to be bidirectional, with (1) variability in SHB impacting GSQ and (2) variability in GSQ impacting compensatory SHB invoked to improve nighttime sleep. Although research has yet to fully disentangle the relationship between SHB and GSQ, the proposed association amongst negative affect, SHB, and sleep problems has received some empirical support in younger participants, as better SHB was related to reduced bedtime resistance in preschoolers with difficult temperament profiles.[39]

Taken together, previous research has revealed that undergraduate students commonly experience sleep problems, and that these sleep problems may be associated with reduced academic achievement[2,3] and mental health issues.[4,5] For these reasons, it is important to examine associations amongst temperament, SHB, and GSQ with the ultimate purpose of identifying ways in which to improve the sleep habits and daytime functioning of university students. To this end, the goals of the present study were threefold: (1) to examine relations between temperament and GSQ in university students broadly recruited, (2) to document associations between SHB and temperament in this sample, and (3) to determine whether associations amongst temperament, SHB, and GSQ were best explained by mediation or moderation models. Based on previous findings,[28,29] we expected that poor GSQ would be associated with increased negative affect and orienting sensitivity as well as reduced effortful control; significant associations were not expected between GSQ and extraversion. Although the existing literature does not allow for any evidence-based predictions regarding associations between temperament and SHB, we predicted similar significant relations to those obtained between temperament and GSQ, given the close relations documented between SHB and GSQ in previous work.[33–35] Finally, based on previous cross-sectional and longitudinal research indicating that inhibitory control predicts SHB,[31,32] we anticipated that the temperament dimension of effortful control would predict variability in SHB, which would then be associated with GSQ. Because temperament is a biologically-based construct that demonstrates considerable stability over time, we expected that mediation would better explain relations amongst temperament, SHB, and GSQ relative to moderation. That is, mediation would suggest that trait-based variability in temperament predisposes individuals to poorer GSQ through alterations in SHB resulting from differential susceptibility to precipitating factors, whereas moderation would suggest that SHB is differentially associated with GSQ for individuals with distinct temperament profiles in the absence of any presumed causal pathways. Specific predictions regarding the other temperament dimensions of extraversion, negative affect, and orienting sensitivity are not proposed given the novelty of the conducted analyses and the limited literature on which to base any hypotheses.

Methods

Participants

Two hundred two undergraduate students between the ages of 18 and 23 years were recruited to participate in an online study from the Social Science Human

Subjects Pool maintained by a large public university in the western United States. The data from approximately 25% participants were excluded for the following reasons: 10% failed to provide complete data on the included questionnaires, 7% incorrectly responded or failed to respond to one or more of two control questions ("do you have more than one birthday" and "are you human"), 3% reported a diagnosis of and/or being treated for one or more psychological disorders, and less than 1% reported being treated for a sleep disorder. The data from 3% of participants were excluded for more than one of the aforementioned reasons.

One hundred fifty-two students were included in the final sample (85% female; mean age = 20 years). Of this sample, 58% of the participants were of Asian descent, 24% were Caucasian, 3% were of mixed race, less than 1% were African American, and less than 1% were American Indian or Alaskan Native. Fourteen percent of participants chose not to report their race. Twenty-five percent of participants identified as Hispanic, including 13% of the participants who did not report their race. Participants received .5 points of extra course credit to apply to an eligible course of their choosing in appreciation for each half hour spent participating in the study.

Measures

Participants completed a battery of online questionnaires that inquired about demographic information, SHB, GSQ, and temperament (additional questionnaires were also included but are not the focus of the present report). The data for each questionnaire were reduced according to the published literature or the relevant data reduction manuals.

Demographic information

The demographic questionnaire created for this study inquired about participant race, ethnicity, age, and sex, among other characteristics.

SHB

The Sleep Hygiene Index (SHI) was used to assess participant SHB.[6] The 13 items on this measure were developed using diagnostic criteria for poor sleep hygiene from the International Classification of Sleep Disorders[40] and are shown in Table 1. Participants were asked to report how often they engaged in each of the listed activities by rating each item on a 5-point scale. The scores on individual items were summed to yield an overall measure of sleep hygiene, with higher scores indicative of poorer SHB ($\alpha = 0.71$).

GSQ

A modified version of the Pittsburgh Sleep Quality Index (PSQI) was used to assess subjective sleep quality over the previous 30 days.[41] The questionnaire includes 19 items that were reduced to yield information on 7 subscales (i.e., daytime dysfunction, nighttime sleep disruptions, nighttime sleep duration, nighttime sleep efficiency, nighttime sleep latency, use of sleep medications, and perceived sleep quality). On the questionnaire used in this research, the scoring options for question 5 were incorrectly listed as never, less than once, once or twice, and three or more times (the correct listings are not during the past month, less than once a week, once or twice a week, and three or more times a week). As a result, we modified the scoring for this question, such that 0 = never or less than once, 1 = once or twice, and 2 = three or more times. Higher scores are associated with poorer GSQ,

Table 1. Correlations between items from the SHI and temperament factor scores.

Item	Effortful control	Extraversion	Negative affect	Orienting sensitivity
1. I take daytime naps lasting two or more hours.	−0.17*	−0.04	0.13	0.20*
2. I go to bed at different times from day to day.	−0.20*	0.02	0.16	0.15
3. I get out of bed at different times from day to day.	−0.14	0.05	0.16	0.09
4. I exercise to the hour of sweating within 1 h of going to bed.	−0.13	−0.02	−0.11	0.06
5. I stay in bed longer than I should two or three times a week.	−0.25*	−0.15	0.19*	0.22*
6. I use alcohol, tobacco, or caffeine within 4 h of going to bed or after going to bed.	−0.20*	0.21*	0.10	−0.05
7. I do something that may wake me up before bedtime (for example: play video games, use the internet, or clean).	−0.16*	0.06	0.10	0.05
8. I go to bed feeling stressed, angry, upset, or nervous.	−0.30*	0.06	0.37*	0.13
9. I use my bed for things other than sleeping or sex (for example: watch television, read, eat, or study).	−0.13	0.13	0.12	0.00
10. I sleep on an uncomfortable bed (for example: poor mattress or pillow, too much or not enough blankets).	−0.11	0.01	0.12	−0.05
11. I sleep in an uncomfortable bedroom (for example: too bright, too stuffy, too hot, too cold, or too noisy).	−0.12	−0.15	0.14	−0.08
12. I do important work before bedtime (for example: pay bills, schedule, or study).	−0.04	0.01	0.20*	0.13
13. I think, plan, or worry when I am in bed.	−0.39*	−0.07	0.43*	0.09

with scores exceeding 5 indicative of categorically poor GSQ[41] ($\alpha = 0.52$, which is similar to that previously reported in university students[29]).

Temperament

The short form of the Adult Temperament Questionnaire (ATQ) was used to assess participant temperament.[42] This questionnaire asks participants to indicate how representative each of 77 statements is of their usual behavior on a 7-point scale (an additional option allows participants to indicate that the statement does not apply to them). The data from the individual items were reduced to yield 13 scales that were further combined to yield four factor scores (identified in reference[42] using exploratory factor analysis). These factor scores are effortful control ($\alpha = 0.78$; including scales pertaining to activation control, attentional control, and inhibitory control), extraversion or surgency ($\alpha = 0.76$; including scales pertaining to high intensity pleasure, positive affect, and sociability), negative affect ($\alpha = 0.83$; including scales pertaining to discomfort, fear, frustration, and sadness), and orienting sensitivity ($\alpha = 0.64$; including scales pertaining to associative sensitivity, affective perceptual sensitivity, and neutral perceptual sensitivity).

Procedure

The conducted research was approved by the relevant university Institutional Review Board. Undergraduates viewed the advertisement for the study online and signed up to participate through the Social Science Human Subjects Pool. Once they registered to participate, they could immediately access the online questionnaire battery through the posted web link. Students indicated their willingness to participate by clicking forward after reading the included study information sheet. Because some of the questions included in this study (but not featured in this report) could be perceived as somewhat sensitive in nature, students were provided with information about how to contact the university counseling center if they experienced any psychological discomfort as a result of their involvement.

Results

Preliminary analyses

As shown in Table 2, correlations were initially conducted to determine whether participant age (coded continuously), sex (0 = male or 1 = female), and ethnicity (0 = non-Hispanic or 1 = Hispanic) were associated with SHB, GSQ, and temperament factor scores. Participant age was marginally positively associated with GSQ. In addition, the analyses revealed one marginal association between participant sex and negative affect and one significant correlation between participant ethnicity and extraversion. Because of the categorical nature of the included sex and ethnicity variables, we conducted follow-up one-way analyses of variance (ANOVAs) to confirm the correlational findings. The findings were substantiated in both instances. Females reported marginally higher levels of negative affect ($4.15 \pm .70$) relative to males (3.84 ± 84): $F(1, 150) = 3.61$, $p = 0.06$, and Hispanic participants reported significantly higher levels of extraversion (4.82 ± 0.64) relative to non-Hispanics (4.54 ± 0.77): $F(1, 150) = 4.25$, $p = 0.04$.

Table 2. Correlations amongst study variables to identify potential covariates.

Questionnaire measures	Age	Sex	Ethnicity
Sleep hygiene behavior	−0.01	0.02	0.01
Global sleep quality	0.14°	0.12	0.00
Temperament factor scores			
Effortful control	0.12	0.01	0.01
Extraversion	−0.06	0.00	−0.17*
Negative affect	−0.10	0.15°	0.04
Orienting sensitivity	−0.01	−0.03	0.01

Note: Participant age was coded continuously from 18 to 23 years, participant sex was coded as 0 = male or 1 = female, and ethnicity was coded as 0 = Hispanic or 1 = non-Hispanic. Significant findings are indicated: * $p < 0.05$ and ° $p < 0.10$.

Because our sample was not balanced by race and included a greater percentage of Asian students than is observed in the United States university population more broadly,[43] we also examined whether participant race (coded as Caucasian, Asian, or other) was associated with SHB, GSQ, and temperament factor scores. One-way ANOVAs conducted by group revealed differences on effortful control: $F(2, 149) = 4.23$, $p = 0.02$, negative affect: $F(2, 149) = 3.73$, $p = 0.03$, and extraversion: $F(2, 149) = 8.32$, $p < 0.0001$. Follow-up pairwise comparisons indicated that Caucasians had higher scores on effortful control (4.62 ± 0.12) and lower scores on negative affect (3.87 ± 0.12) relative to Asians (effortful control: 4.20 ± 0.08; negative affect: 4.24 ± 0.08; $ps < 0.01$). Both Caucasians (4.89 ± 0.12) and individuals of other races ($4.88 \pm .14$) had higher scores on extraversion relative to Asians (4.41 ± 0.08; $ps < 0.003$). In all cases, the scores of other races did not differ from those of Caucasians or Asians. Significant or marginal associations were not found between demographic characteristics and SHB.

Because participant age, sex, race, and ethnicity were associated with temperament factor scores in the present research, these variables were included as

covariates in the following analyses. Significant effects are presented when $p < 0.05$.

Correlations between sleep and temperament

Partial correlations between individual items on the SHI and the temperament factor scores are shown in Table 1; partial correlations between sleep variables (SHB and GSQ) and the temperament factor scores and scales are shown in Table 3.

SHB

When considering individual items on the SHI, effortful control was negatively associated with daytime napping, varied bedtimes, staying in bed longer than necessary, substance use (e.g., alcohol or caffeine) before bed, engaging in wake-inducing activities before bed, experiencing negative emotions at bedtime, and planning or ruminating before bed. Negative affect was positively associated with staying in bed longer than necessary, experiencing negative emotions at bedtime, completing cognitively-demanding activities before bed, and planning or ruminating before bed. Fewer associations were found between the temperament dimensions of extraversion and orienting sensitivity in relation to individual items on the SHI. For example, extraversion was only positively associated with substance use before bed, whereas orienting sensitivity was positively related to daytime napping and staying in bed longer than necessary.

When considering the SHB composite on the SHI, poorer SHB was associated with reduced effortful control as well as with reduced scores on each of the scales that contributed to this factor (including activation control, attentional control, and inhibitory control). Poorer SHB was also related to increased negative affect along with increased scores on each of the scales that contributed to this factor (including discomfort, fear, frustration, and sadness). SHB was unrelated to scores on the extraversion factor score but was positively related to one scale that contributed to this factor (high intensity pleasure, with no associations found with positive affect or sociability). Finally, SHB was unassociated with the orienting sensitivity factor score and all of the scales that contributed to this factor (including activation control, attentional control, and inhibitory control).

Table 3. Partial correlations between sleep variables and temperament factors and scales.

Temperament factors and scales	Sleep hygiene behavior	Global sleep quality
Effortful control	−0.37*	−0.32*
Activation control	−0.26*	−0.25*
Attentional control	−0.39*	−0.37*
Inhibitory control	−0.22*	−0.12
Extraversion	0.02	−0.09
High intensity pleasure	0.17*	0.10
Positive affect	−0.02	−0.17*
Sociability	−0.08	−0.13
Negative affect	0.34*	0.13
Discomfort	0.17*	0.01
Fear	0.31*	0.16*
Frustration	0.22*	0.02
Sadness	0.27*	0.17*
Orienting sensitivity	0.14	0.12
Affective perceptual sensitivity	0.15	0.10
Associative sensitivity	0.16	0.05
Neutral perceptual sensitivity	−0.03	0.09

Note: Correlations were conducted controlling for participant age (coded continuously from 18 to 23 years), sex (coded as 0 = male or 1 = female), race (with two dummy-coded variables accounting for Caucasian, Asian, or other races), and ethnicity (coded as 0 = Hispanic or 1 = non-Hispanic). Significant findings are indicated: * $p < 0.05$.

GSQ

Poorer GSQ was associated with reduced effortful control as well as with reduced scores on two of the three scales that contributed to this factor score (including activation control and attentional control, but not inhibitory control). Although poorer GSQ was not related to increased negative affect, GSQ was positively associated with two of the four scales that contributed to this factor (including fear and sadness, but not discomfort or frustration). GSQ was unrelated to the extraversion factor score but was negatively related to one scale that contributed to this factor (including positive affect, but not high intensity pleasure or sociability). Finally, GSQ was unassociated with the orienting sensitivity factor score and all of the scales that contributed to this factor (including activation control, attentional control, and inhibitory control).

Mediation analyses

Simple mediation models were tested using Model 4 of the regression-based approach outlined in reference[44] to determine whether SHB mediated the association between temperament factor scores and GSQ. Mediation was indicated when bias-corrected bootstrap confidence intervals ($k = 10{,}000$ resamples) did not include zero. Participant age (coded continuously), sex (0 = male or 1 = female), race (with two dummy-coded variables accounting for Caucasian, Asian, or other races), and ethnicity (0 = Hispanic or 1 = non-Hispanic) were included as covariates in each analysis.

Effortful control

As shown in Figure 1, Panel A, effortful control was negatively associated with SHB and SHB was

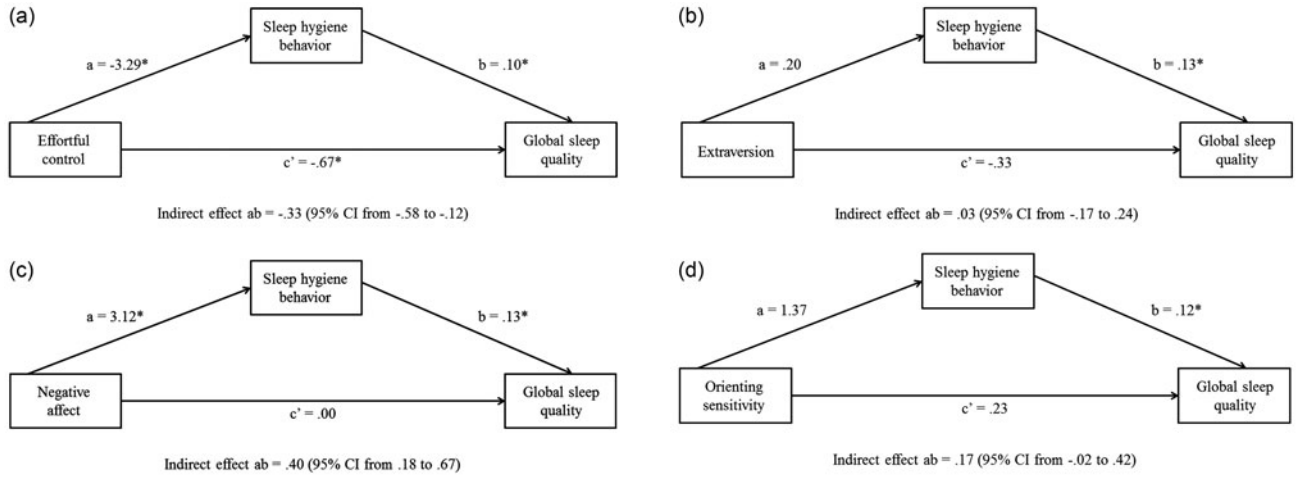

Figure 1. **A.** Depiction of the simple mediation analysis conducted to determine whether SHB mediated the association between effortful control and GSQ. Covariates were included in the model as described in the Results section. Significant effects are indicated: * $p < 0.05$. **B.** Depiction of the simple mediation analysis conducted to determine whether SHB mediated the association between extraversion and GSQ. Covariates were included in the model as described in the Results section. Significant effects are indicated: * $p < 0.05$. **C.** Depiction of the simple mediation analysis conducted to determine whether SHB mediated the association between negative affect and GSQ. Covariates were included in the model as described in the Results section. Significant effects are indicated: * $p < 0.05$. **D.** Depiction of the simple mediation analysis conducted to determine whether SHB mediated the association between orienting sensitivity and GSQ. Covariates were included in the model as described in the Results section. Significant effects are indicated: * $p < 0.05$.

positively related to GSQ. The direct effect of effortful control on GSQ was statistically significant, as was the indirect effect of effortful control on GSQ through SHB.

Extraversion

As shown in Figure 1, Panel B, extraversion was unassociated with SHB but SHB was positively associated with GSQ. Neither the direct effect of extraversion on GSQ nor the indirect effect of extraversion on GSQ through SHB was statistically reliable.

Negative affect

As shown in Figure 1, Panel C, negative affect was positively associated with SHB and SHB was positively related to GSQ. The direct effect of negative affect on GSQ was not significant, whereas the indirect effect of negative affect on GSQ through SHB was statistically reliable.

Orienting sensitivity

As shown in Figure 1, Panel D, orienting sensitivity was unassociated with SHB, but SHB was positively associated with GSQ. Neither the direct effect of orienting sensitivity on GSQ nor the indirect effect of orienting sensitivity on GSQ through SHB was statistically reliable.

Moderation analyses

Moderation models were tested using Model 1 of the regression-based approach outlined in reference44 to examine whether SHB impacted the association between temperament factor scores and GSQ. The temperament and sleep hygiene variables were mean-centered before analysis to allow for meaningful interpretation of the resulting coefficients. Participant sex, race, and ethnicity were included as categorical covariates in each analysis.

Effortful control

As shown in Figure 2, Panel A, the effect of effortful control on GSQ was significant, as was the effect of SHB on GSQ. The interaction between effortful control and SHB in predicting GSQ was not significant, however.

Extraversion

As shown in Figure 2, Panel B, the effect of extraversion on GSQ was not significant, although the effect of SHB on GSQ was statistically reliable. The interaction between extraversion and SHB in predicting GSQ was not significant, however.

Negative affect

As shown in Figure 2, Panel C, the effect of negative affect on GSQ was not significant, although the effect

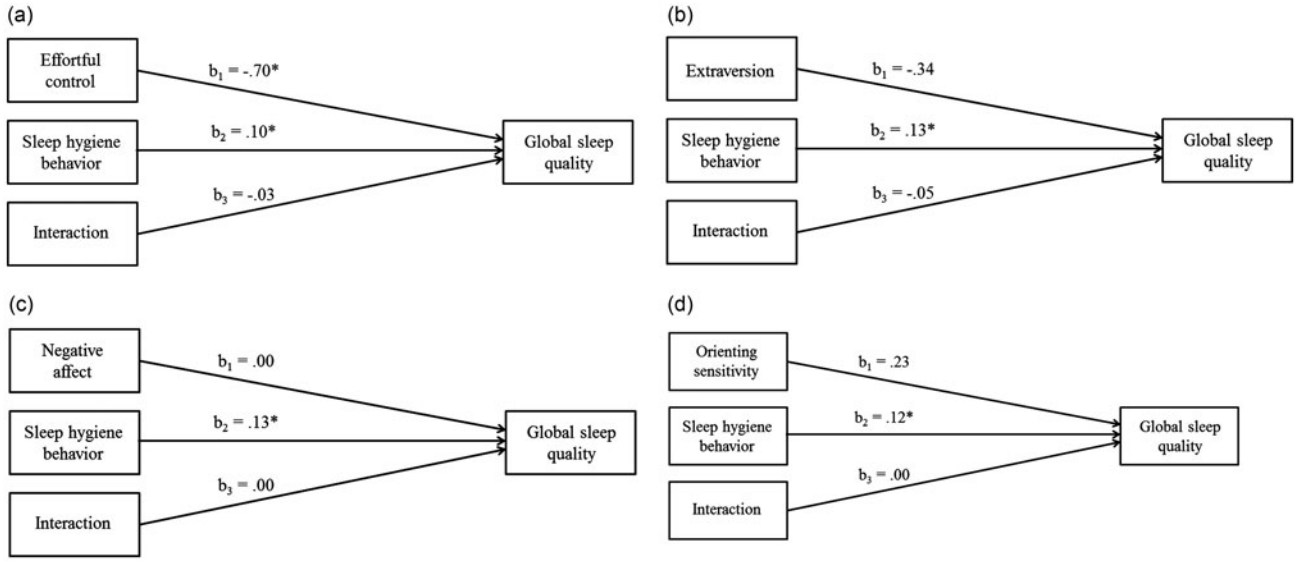

Figure 2. **A.** Depiction of the moderation analysis conducted to determine whether SHB moderated the effect of effortful control on GSQ. Covariates were included in the model as described in the Results section. Significant effects are indicated: * $p < 0.05$. **B.** Depiction of the moderation analysis conducted to determine whether SHB moderated the effect of extraversion on GSQ. Covariates were included in the model as described in the Results section. Significant effects are indicated: * $p < 0.05$. **C.** Depiction of the moderation analysis conducted to determine whether SHB moderated the effect of negative affect on GSQ. Covariates were included in the model as described in the Results section. Significant effects are indicated: * $p < 0.05$. **D.** Depiction of the moderation analysis conducted to determine whether SHB moderated the effect of orienting sensitivity on GSQ. Covariates were included in the model as described in the Results section. Significant effects are indicated: * $p < 0.05$.

of SHB on GSQ was statistically reliable. Nevertheless, the interaction between negative affect and SHB in predicting GSQ was not significant.

Orienting sensitivity

As shown in Figure 2, Panel D, the effect of orienting sensitivity on GSQ was not significant, although the effect of SHB on GSQ was significant. The interaction between orienting sensitivity and SHB in predicting GSQ was not significant, however.

Discussion

The purpose of the present study was to examine two potential correlates of poor GSQ in university students, namely temperament and SHB, and the pathways through which they are related to GSQ. Specifically, the goals of the conducted research were: (1) to extend previous findings[29] by examining associations between GSQ and temperament in university students broadly recruited, (2) to examine associations between SHB and temperament in this sample, and (3) to determine whether associations amongst temperament, SHB, and GSQ were best explained by mediation or moderation models. The results of this research are significant in that they: (1) replicate and extend previous findings on sleep-temperament associations in university students, (2) provide the first indication of significant associations between SHB and temperament in this population, and (3) document at least one way in which SHB, GSQ, and temperament are related.

The present study yielded findings that were remarkably consistent with those found previously.[29] When considering the correlations between sleep and temperament factor scores, our results also indicated that reduced GSQ was associated with reduced effortful control; in addition, we replicated the non-significant relation between GSQ and extraversion. The two discrepant correlational findings concerned negative affect and orienting sensitivity: previous research[29] found that poorer GSQ was associated with increased negative affect and orienting sensitivity, whereas no relations were observed between these variables in the present study. Future research should be conducted to further explore these potential associations, as relations between GSQ and orienting sensitivity in infancy may differ in kind from those identified in young adulthood.

Although replication is critical in psychological research,[45] the novelty of the present study is in our examination of associations between SHB and temperament. Although SHB has not been previously studied in relation to temperament, there is reason to believe that variability in temperament may predispose individuals to differentially engage in SHB. In

particular, previous research suggests that aspects of executive functioning or effortful control should be associated with engagement in SHB.[31,32] We also predicted that, given the close relations documented between SHB and GSQ in previous work,[33–35] significant correlations would parallel those found between GSQ and temperament. This pattern of effects was realized, as poorer SHB was associated with increased negative affect and reduced effortful control; extraversion and orienting sensitivity were unrelated to SHB.

Because associations between temperament and SHB likely vary in association with the ways in which SHB is defined, we examined associations between particular indicators of SHB and temperament factor scores. The results revealed that higher scores on the SHI were primarily negatively correlated with effortful control and positively correlated with negative affect, with nominally fewer associations with extraversion and orienting sensitivity. In particular, negative affect was positively associated with questions assessing hyperarousal at bedtime (i.e., feeling stressed or upset; worrying or ruminating) whereas effortful control was negatively associated with these and other indicators of hyperarousal at bedtime (i.e., engaging in arousing activities like cleaning or playing video games) in addition to sleep scheduling (i.e., going to bed at the same time from night to night; avoiding lengthy daytime naps) and substance use before bed. These divergent associations suggest that high negative affect and lower effortful control might independently predispose individuals to ruminating or focusing on negative daytime events before bed. On the other hand, higher effortful control is associated with better planning of sleep schedules and the avoidance of activities that might impair the likelihood of obtaining adequate nighttime sleep. Although future research is needed to confirm this possibility, better effortful control might allow individuals the cognitive and behavioral control to practice more effective SHB, which may ultimately result in better GSQ. This research adds to this literature by suggesting that temperament might serve to influence the implementation of various SHB, ultimately impacting GSQ. In this way, temperament dimensions that contribute to the implementation of better SHB are indirectly associated with improved GSQ, whereas temperament dimensions that contribute to poorer SHB are indirectly related to reduced GSQ. Additional research should be conducted to further examine associations between temperament and SHB using other inventories as well as using questionnaires that include distinct subscales of SHB to better understand how these different variables are related.

When considering the results from the mediation and moderation analyses, mediation was found when effortful control and negative affect were considered as predictors; evidence of moderation was not obtained. As expected, poorer SHB mediated the association between decreased effortful control and reduced GSQ. These findings are in agreement with those published previously.[31,32,46,47] Although we did not make specific predictions about the significant pathways explaining associations for the other three temperament factor scores, similar evidence of mediation was found when considering negative affect. In both cases, temperament influenced GSQ through SHB. Specifically, participants with decreased effortful control and increased negative affect reported poorer SHB, resulting in reduced GSQ. Evidence of mediation was not obtained when extraversion or orienting sensitivity were included as predictors, and moderation analyses revealed no association between temperament and SHB in predicting GSQ.

Taken together, the presented findings are important for two reasons: (1) they indicate that variability in SHB explains associations between temperament and GSQ, as indicated by significant mediation models, and (2) that variability in SHB is not associated with the strength of relations between temperament and GSQ, as indicated by the absence of moderation. Although mediation models are used to test presumed causal relations amongst the included variables, additional experimental work is needed to confirm causality in the present study, given the cross-sectional nature of this research. Nevertheless, future research should also be conducted (1) to examine whether reducing negative affect and improving effortful control may positively influence engagement in SHB and, subsequently, ratings of GSQ and (2) to determine whether targeting SHB associated with increased negative affect and reduced effortful control serve to promote better GSQ. As suggested by the 3 P model,[37] interventions designed to reduced negative affect and improve effortful control might reduce individual susceptibility to or improve the ability to cope with life stressors that might otherwise serve as precipitating events. Although temperament is generally viewed as stable in adulthood,[48] researchers could attempt to reduced university student depression or enhance executive functioning through behavioral training programs in an effort to improve SHB.[49] Other work should focus on reducing problematic SHB associated with various temperament dimensions. For example, researchers could attempt to reduce nighttime stress and worry in individuals high on negative affect and low on effortful control while also

specifically promoting the importance of maintaining a sleep schedule and reducing daytime naps in those low on effortful control. Such research should also examine interactions amongst negative affect and effortful control in predicting reactivity to stressful life events, SHB, and GSQ.[50]

In addition to extending the findings presented herein, future research should also address the limitations of the present study. One unique feature of the presented research is that over 50% of the participants were of Asian descent. Although comparable to the diversity within the broader student body at the university from which the participants were recruited,[51] only approximately 7% of university students across the United States are of Asian descent.[43] We addressed this discrepancy by including race as a categorical covariate in the presented analyses, but future research should more directly examine whether the associations reported herein differ by race. Findings of distinct associations by race could be used to make data-driven recommendations about relations among temperament, SHB, and GSQ to universities based on their demographic characteristics.

Finally, future research should include objective measures of sleep quality, perhaps obtained through actigraphy, in addition to the self-report measures presented here. Previous research has indicated that measures of GSQ obtained from the PSQI do not correlate with objective measures of sleep as assessed by actigraphy[52,53] and/or through polysomnography,[53] but do correlate with self-report measures of psychological well-being.[52,53] As such, the PSQI may not specifically reflect sleep disturbances but might instead be an indicator of general dissatisfaction.[53] Future research should include both objective and subjective measures of sleep quality to determine whether the associations documented herein reflect actual associations amongst temperament, SHB, and GSQ, or whether the observed relations are solely in the eye of beholder. Indeed, either outcome is practically and theoretically significant, but will result in distinct recommendations for interventions designed to improve student functioning. Given the known limitations of cross-sectional data, additional research should also include experimental and longitudinal methods to better understand causal and longitudinal associations, respectively, amongst participant temperament, SHB, and GSQ.

Conclusions

Taken together, the presented findings add to the existing literature by (1) confirming and extending previous associations between GSQ and temperament factors in a sample of university students broadly recruited, (2) documenting associations between SHB and temperament, and (3) providing information concerning the pathways through which these variables are related. These results indicate that certain aspects of temperament (effortful control and negative affect) may predict individual variability in GSQ through their influence on SHB, and that variability in SHB does not moderate the effect of temperament factor scores on GSQ. As researchers conduct additional studies to extend these findings, their focus should be on (1) confirming causality and (2) developing practices to improve undergraduate GSQ by reducing negative affect and increasing effortful control or by improving SHB that are uniquely associated with these temperament profiles.

Acknowledgements

We are grateful to the students who participated in this research as well as to the members of the UCI Memory and Development Lab who assisted with questionnaire scoring and data reduction.

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