Nature and Science of Sleep

Dovepress
open access to scientific and medical research

Open Access Full Text Article

ORIGINAL RESEARCH

Perceived Stress, but Not Rumination, Mediates the Relationship Between Trait Mindfulness and Sleep Quality in Young Adults

Jaimee K Miller, Simon L Evans

School of Psychology, Faculty of Health and Medical Sciences, University of Surrey, Guildford, GU2 7XH, UK

Correspondence: Jaimee K Miller, Email jaimeekmiller@outlook.com

Objective: Poor sleep among young adults is prevalent, yet the mediating variables are largely understudied, and there is limited relevant work utilizing objective sleep measures. The present study investigated the mediating effects of perceived stress and rumination in the relationship between trait mindfulness and subjective and objective sleep quality in young adults.

Methods: A total of 170 healthy adults (aged 18–37, $M = 20.8$, $SD = 2.9$) self-reported on trait mindfulness, perceived stress, and rumination. The primary ($N = 140$) and secondary ($N = 30$) samples both completed the Pittsburgh Sleep Quality Index (PSQI) to assess subjective sleep quality. The secondary sample ($N = 30$) additionally provided sleep diaries, as well as wrist-worn actigraphy data for assessing objective sleep quality. A mediation analysis was conducted to assess the effect of trait mindfulness on sleep quality with perceived stress and rumination as mediators.

Results: Trait mindfulness was positively associated with better subjective sleep quality; this was fully mediated by perceived stress, $b = -0.08$, 95% CI [−.12, −0.06]. Rumination was negatively associated with subjective sleep quality but did not mediate the relationship between trait mindfulness and sleep quality, $b = -0.01$, 95% CI [−.03, 0.02]. Only trait mindfulness was correlated with diary-based sleep ratings, and none of the measures were associated with actigraphy-based sleep quality.

Conclusion: This study indicates that perceived stress is an important mediator in the relationship between trait mindfulness and subjective sleep quality among young adults, rather than rumination. These findings have implications for mindfulness-based therapeutic approaches to address the high prevalence of sleep disorders among young adults, adding mechanistic detail to the literature.

Keywords: mindfulness, perceived stress, rumination, sleep

Introduction

Poor sleep among the general population is prevalent and rising.[1,2] Notably, up to 50% of young people rate their sleep quality as poor, and a majority are chronically sleep deprived.[3] The negative mental health outcomes of poor sleep have been consistently documented, including links to anxiety, mood disorders, substance use, impulsivity, and aggression,[3–6] alongside links to physical health risks such as lower immunity, cancer, cardiovascular disease, and type 2 diabetes.[7,8] Current National Institute for Health and Care Excellence (NICE) guidelines recommend face-to-face Cognitive Behavioral Therapy for Insomnia (CBT-I) as first-line treatment for insomnia.[9] Yet, this is currently not readily available in the UK, and there is no direct evidence comparing alternative online self-help programs eg Sleepio with face-to-face CBT-I.[9] Additionally, CBT-I has a non-response rate of up to 40% and a high remission rate.[10] Alternatively, short-term pharmacological treatment for insomnia is advised;[11] short-term effects are comparable to CBT-I, and combined, the two treatments have increased efficacy.[12] However, pharmacological treatment comes with disadvantages including a variety of side effects and risk of dependency.[9,12] Furthermore, insomnia typically returns following withdrawal of pharmacological treatment and a meta-analysis found that the effects of long-term pharmacological treatment may decrease over time.[12] Hence, there is growing

Received: 29 November 2023
Accepted: 12 May 2024
Published: 24 July 2024

interest in alternative therapies for reducing sleep problems, such as mindfulness-based interventions (MBIs), which have shown efficacy comparable to CBT-I with high adherence, and no adverse side effects.[13,14]

Higher trait mindfulness – an individual's innate tendency to purposefully maintain awareness of the present moment in an open-minded and non-evaluative manner[15] – has been linked to a range of positive physical and mental health outcomes including better sleep in a recent meta-analysis.[16] There is also evidence that sleep quality serves as a mediator in the relationship between trait mindfulness and better wellbeing, and other research has identified sleep quality as a mediator in the relationship between trait mindfulness and physical health.[17,18] These findings highlight the important role of sleep quality in explaining the influence of trait mindfulness on both mental and physical health; however, the relationship between sleep quality and trait mindfulness is not well understood. Cross-sectional[19–21] and experimental[22] studies investigating the relationship between trait mindfulness and sleep quality have identified psychological distress, eg perceived stress, as a mediating variable. However, this has only been investigated using subjective sleep measures, and not in young adults specifically. There is evidence indicating that subjective and objective sleep measures do not always correlate, perhaps due to underreported sleep duration and overestimated sleep latency.[23,24] Given the prevalence and implications of poor sleep among young adults in particular, the relationship between trait mindfulness and sleep quality, and the potential mediating variables, requires further attention.

Factor analyses have led to the conceptualization of trait mindfulness as comprising five facets; mindfulness is the act of *observing* or attending to internal and external experiences and *describing* these with *awareness* of the present moment. This is done with *non-judgement* of thoughts and feelings and *non-reactivity*; allowing these to come and go.[25] The Five Facets of Mindfulness Questionnaire (FFMQ) was designed to measure mindfulness at the facet level and is widely used.[25,26] In adults with insomnia, higher levels of *awareness* have been linked to less severe symptoms of insomnia, less sleep disturbance, and fewer dysfunctional beliefs about sleep; *non-judging* was also associated with fewer dysfunctional beliefs about sleep, and both *non-judging* and *non-reactivity* were linked to less sleep difficulty.[27] Likewise, Xie et al found that *awareness*, *non-judging*, and *non-reactivity* were associated with better sleep health.[28] These findings suggest that *awareness*, *non-judging*, and *non-reactivity* play key roles in influencing sleep quality. It is proposed that *awareness* is necessary to allow modification of thoughts.[29] Ong et al's Meta-cognitive Model of Insomnia posits that primary arousal, involving negative beliefs and attitudes about sleep, directly inhibits sleep.[30] The theory describes an iterative process whereby secondary arousal, including *awareness* of negative beliefs and attitudes, and attachment to them, further precipitates negative cognition, ultimately resulting in further sleep difficulties. Acceptance (*non-judging* and *non-reactivity*) deactivates hyperarousal, shifting meta-cognition to a more objective and adaptive state, thus reducing sleep difficulties.

On the other hand, it is well established that high levels of perceived stress negatively impact sleep quality.[31–33] Perceived stress refers to the extent to which an individual finds their life unpredictable, uncontrollable, and overloaded.[34] Extensive cross-sectional[35,36] and longitudinal[37] evidence demonstrates a relationship between perceived stress and poor sleep quality, using a variety of self-report and objective measures.[38–41] Perceived stress has also been associated with lower levels of trait mindfulness.[42] It is thought that mindfulness mitigates stress appraisals and stress reactivity responses, in turn enhancing sleep quality, and other health outcomes.[43–45] This may explain why perceived stress appears to mediate the relationship between trait mindfulness and sleep quality,[19–21] and provides a rationale for exploring this in more detail, and with inclusion of objective sleep measures.

There is also considerable evidence that rumination, defined by Trapnell & Campbell as "a self-attentiveness motivated by perceived threats, losses or injustices to the self"[46] negatively impacts sleep quality due to heightened cognitive and physiological activity prior to sleep onset.[47–49] This has been attributed to the negatively toned cognitive arousal associated with rumination, eg repeatedly contemplating the causes and outcomes of a stressful event after it has occurred, with negative self-focus.[50,51] Like perceived stress, previous studies have shown that rumination impacts sleep quality based on both subjective,[52] and objective measures,[53,54] affecting sleep latency,[55] disturbance,[56] duration,[57] and efficiency,[58] consequently increasing daytime dysfunction.[59] The opposing roles of mindfulness and rumination are not surprising since these are theoretically opposing constructs, which are negatively correlated.[60] The Monitor and Acceptance Theory suggests that mindfulness may counteract rumination: attention monitoring (*observing*), alongside acceptance (*non-judging* and *non-reactivity*) can inhibit the negative emotional and cognitive mechanisms linked to

rumination.[61] Given the interrelations between trait mindfulness, perceived stress, and rumination, this provides a rationale for exploring rumination as another possible mediator in the relationship between trait mindfulness and sleep quality. Rumination has been found to mediate the relationship between mindfulness and poor sleep quality in a previous study.[62] The present study is the first to consider both rumination and perceived stress as potential mediators in the relationship between trait mindfulness and sleep quality.

Present Study

Within the literature, there is compelling evidence suggesting that mindfulness, perceived stress, and rumination each play a role in sleep quality; however, there are limited studies looking into the interaction between these variables and the impact on sleep quality. To date, no study has investigated the mediating effects of both perceived stress and rumination on the relationship between trait mindfulness and sleep quality in young adults, nor has this been investigated with the use of objective sleep measures.

Thus, we sought to add mechanistic detail to the literature. Data were collected from a sample of UK-based healthy young adults. Both subjective (the Pittsburgh Sleep Quality Index [PSQI][63] and the Consensus Sleep Diary)[64] and objective (wrist-worn actigraphy) measures of sleep quality were employed.

It is hypothesized that i) higher self-reported mindfulness will be associated with lower self-reported perceived stress, lower self-reported rumination, and better subjective sleep quality (measured by the PSQI); ii) higher self-reported rumination will be associated with higher self-reported perceived stress, and iii) both self-reported perceived stress and rumination will be associated with poorer subjective sleep quality (measured by the PSQI). We further hypothesized that iv) perceived stress and rumination will mediate the relationship between trait mindfulness and subjective sleep quality (measured by the PSQI). In a secondary sample, we explored whether these hypotheses held when sleep quality was assessed using sleep diary- and actigraphy-based methods.

Method

Participants

Data were obtained from 170 participants, aged 18–37 (M = 20.8, SD = 2.9); 145 self-identified as females, 23 self-identified as males, and 2 self-identified as other (see Table 1 for demographics and Supplementary Table 1 for further details). The dataset comprised 2 subsamples: the primary sample (N = 140) who completed a subjective sleep questionnaire only, and the secondary sample (N = 30) who completed sleep diaries and actigraphy measures in addition to the measures completed by the primary sample. An a priori G*Power analysis with a significance criterion of $\alpha = 0.05$ and power = 0.80 indicated an ideal sample of 192 participants for a medium effect size ($f^2 = 0.0638$) in a mediation analysis with 4 predictors. Participants were recruited through volunteer sampling via email and flyers distributed across the University of Surrey campus. Inclusion criteria were age range (18–40 years old), and the secondary sample excluded those who had practiced mindfulness regularly before.

Table 1 Demographics of All Participants (N = 170)

Demographic		N	Percent (%)	M	SD
Gender	Male	23	13.5		
	Female	145	85.3		
	Other	2	1.2		
Age				20.8	2.9
Ethnicity	White	100	58.8		
	Black	3	1.8		
	Asian	20	11.8		
	Mixed-race	10	5.9		
	Other	4	2.4		
	Unknown	33	19.4		

Measures

Subjective sleep quality was assessed through the PSQI[63] in both samples, and in the secondary sample through the Consensus Sleep Diary;[64] objective sleep quality was measured in the secondary sample through wrist-worn actigraphy.

The PSQI is a 19-item self-report questionnaire that retrospectively assesses seven components of subjective sleep (perceived quality, latency, duration, efficiency, disturbance, medication, and daytime dysfunction) over the past month. A global sleep quality score is calculated which ranges from 0 to 21; scores above 5 indicate poor sleep quality.[63] High internal validity for this measure has previously been reported using Cronbach's alpha ($\alpha = 0.83$).[63]

The Consensus Sleep Diary captures subjective sleep quality through bedtime, time tried to go to sleep, sleep latency (time taken to fall asleep, minutes), number and length of awakenings (minutes), wake time, rise time and self-rated sleep quality.[64] Sleep quality is rated on a 5-point Likert scale, 0 (*very good*), 1 (*good*), 2 (*fair*), 3 (*poor*), and 4 (*very poor*). The Consensus Sleep Diary was completed directly after awakening for seven days.

Participants in the secondary sample wore a tri-axial GENEActiv actigraphy device (Activinsights Ltd., Kimbolton, England) for seven days. The devices were placed on the non-dominant wrist. The data were summarized into 30-second epochs and analyzed using the GENEActiv Software based on gross motor movement, body temperature, and light exposure, to estimate total elapsed sleep time (time between falling asleep and waking, minutes), sleep duration (actual time spent asleep, minutes), number of activity periods after sleep onset, median activity period (minutes), and sleep efficiency (%).

Mindfulness was assessed through the 24-item short form of the Five Facets of Mindfulness Questionnaire (FFMQ-SF) which measures five facets of mindfulness (*observing, describing*, acting with *awareness, non-judging* of inner experience, and *non-reactivity* to inner experience) on a 5-point Likert scale, 1 (*never or very rarely true*), 2 (*rarely true*), 3 (*sometimes true*), 4 (*often true*), and 5 (*very often or always true*).[65] All five facets have good internal validity with Cronbach's alpha coefficients ranging from 0.73 to 0.91.[65] Respondents are scored on each facet as well as a total mindfulness score that ranges from 24 to 120; high scores indicate high levels of mindfulness.

Perceived stress was measured through the Perceived Stress Scale (PSS), which is a widely used 10-item measure of stress perception with high internal validity ($\alpha = 0.78$).[34] The measure uses a 5-point Likert scale, 0 (*never*), 1 (*almost never*), 2 (*sometimes*), 3 (*fairly often*), and 4 (*very often*), to assess perceived stress levels over the last month. This is based on a total score ranging from 0 to 40 with high scores indicating high levels of perceived stress.

The Rumination-Reflection Questionnaire (RRQ) is a 21-item measure of rumination and reflection. Only the rumination sub-scale was utilized in this study, which has exceptionally high internal validity with a Cronbach's alpha coefficient of 0.90.[46] Items are scored on a 5-point Likert scale, 1 (*strongly disagree*), 2 (*disagree*), 3 (*neutral*), 4 (*agree*), and 5 (*strongly agree*), and averaged; high scores indicate high levels of rumination.

Procedure

Prior to data collection, favorable ethical opinion was obtained from the London-Surrey NHS Research Ethics Committee and the University of Surrey Ethics Committee. All participants were provided with information sheets outlining the aims of the study, and informed consent was acquired prior to data collection. All participants completed the PSQI, FFMQ-SF, PSS, and RRQ via a Qualtrics online survey. Participants in the primary sample were able to access the survey through a link in the recruitment email, while those in the secondary sample visited the Research Centre to complete the online survey and collect a GENEActiv watch and a copy of the Consensus Sleep Diary, along with instructions. All participants were debriefed upon completion of the study.

Data Analysis Plan

Data were analyzed using IBM SPSS version 27; a p value of <0.05 was considered statistically significant. There were no outliers within the dataset, with all z-scores falling within the cut-off points of ± 3.29.[66] Questionnaire measures were completed in full by all participants and for analyses of questionnaire measures the two samples were combined ($N = 170$). Pearson's correlations were used to assess relationships between the questionnaire measures as all z-scores for skewness and kurtosis were within the cut-off points of ± 3.29.[67] From the secondary sample ($N = 30$), only 23 participants provided seven

valid days of actigraphy data, and only 21 participants provided complete sleep diaries; incomplete responses were excluded from analyses. To assess relationships between diary- and actigraphy-based sleep quality and the other measures, both Spearman's and Pearson's correlations were used, as diary-based sleep latency, efficiency and self-rated quality, and actigraphy-based efficiency were non-normally distributed (see Supplementary Table 2). Bonferroni correction was used to control for family-wise error in multiple correlations. Mediations were assessed using model four in PROCESS version 3.5 for SPSS. The mediation model is depicted in Figure 1. Assumptions of accuracy, normality, linearity, multicollinearity, homogeneity, and homoscedasticity were met. The indirect effects and 95% confidence intervals were calculated based on 5000 bootstrap samples; effects were considered significant if confidence intervals did not overlap with zero. Mediations based on diary- and actigraphy-based sleep quality could not be assessed due to a lack of significant correlations with trait mindfulness and perceived stress.

Results

Data Cleaning

From the sleep diaries, sleep duration and efficiency were calculated (see Reed & Sacco for equation);[68] seven-day averages were created for latency, duration, number of awakenings, efficiency, and self-rated quality. Bedtime and wake time reported in the sleep diaries were used to correct the estimated times from the actigraphy devices when the disparity was more than 30 minutes, subsequently adjusting actigraphy-based elapsed sleep time, duration, and efficiency. Actigraphy data for duration, number of activity periods and efficiency were averaged across the seven nights.

Descriptive Statistics

For participant characteristics, see Table 1 (further details in Supplementary Table 1).

Overall, only 64.71% of participants scored <5 out of 21 (indicating good sleep quality) on the PSQI, see Table 2. In the secondary sample, who completed sleep diaries, 70.8% of participants self-rated their sleep quality as fair or poor (averaged across the 7 days), despite the average reported sleep duration being nearly 7.5 hours and sleep efficiency averaging >85%. However, the average objective sleep duration and efficiency from actigraphy was lower, indicating that participants overestimated their actual sleep time and efficiency. See Supplementary Tables 3–5 for minimums, maximums, means, standard deviations, medians, interquartile ranges, and gender differences for all measures.

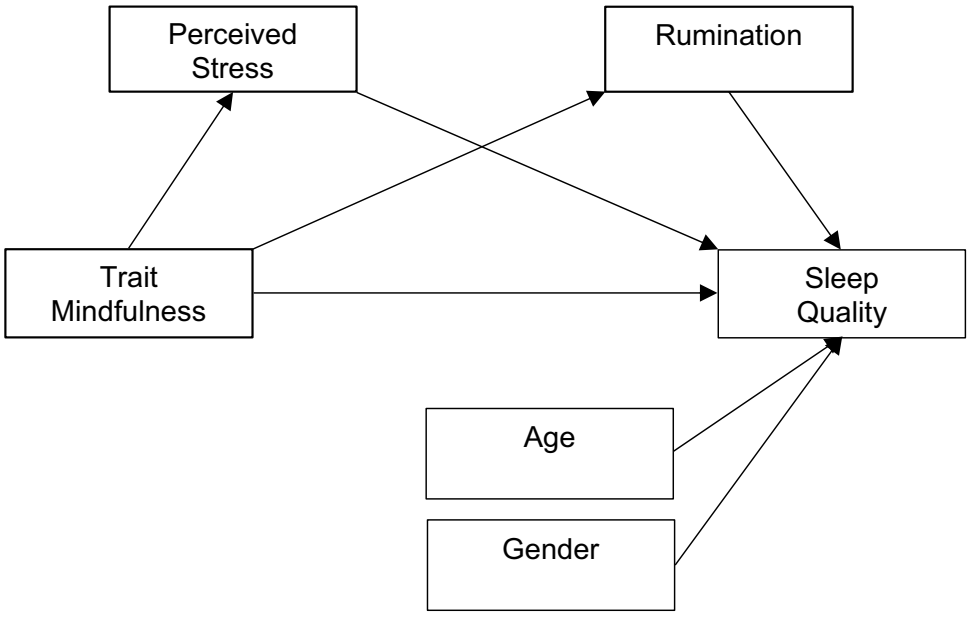

Figure 1 Hypothesized mediation between trait mindfulness, sleep quality, perceived stress, and rumination.

Table 2 Minimums, Maximum, Means, and Standard Deviations (SD) for All Self-Report Measures

Measure (N = 170)	Min	Max	M	SD
Global PSQI	4.00	11.00	6.89	2.16
PSS	10.00	32.00	21.79	5.50
Rumination	2.42	4.67	3.90	0.56
FFMQ-SF Total	55.00	100.00	71.84	11.94
Non-judging	6.00	23.00	14.37	4.87
Non-reactivity	7.00	21.00	14.11	3.46
Awareness	6.00	24.00	13.42	3.95
Observing	9.00	20.00	13.74	3.00
Describing	10.00	25.00	16.21	4.18

Notes: PSQI = Pittsburgh Sleep Quality Index,[63] PSS= Perceived Stress Scale,[34] Rumination measured by the Rumination Reflection Questionnaire,[46] FFMQ-SF = Five Facets of Mindfulness Questionnaire Short Form.[65]

Main Analysis

Pearson's correlation analyses showed that trait mindfulness was negatively correlated with perceived stress, $r(168) = -0.63$, $p < 0.001$, rumination, $r(168) = -0.55$, $p < 0.001$, and global PSQI scores, $r(168) = -0.50$, $p < 0.001$. There was a moderate positive association between perceived stress and rumination, $r(168) = 0.55$, $p < 0.001$. Both perceived stress, $r(168) = 0.62$, $p < 0.001$, and rumination, $r(168) = 0.41$, $p < 0.001$, were positively associated with global PSQI scores. All six comparisons remained significant at a Bonferroni's adjusted alpha level of 0.008.

Facets of Mindfulness and Perceived Stress

Non-judging, $r(168) = -0.45$, $p < 0.001$, *non-reactivity,* $r(168) = -0.48$, $p < 0.001$, *awareness*, $r(168) = -0.46$, $p < 0.001$, and *describing*, $r(168) = -0.47$, $p < 0.001$, were significantly correlated with perceived stress in the expected negative direction, at a Bonferroni's adjusted alpha level of 0.008. However, *observing* was not significantly correlated with perceived stress.

Facets of Mindfulness and Rumination

Non-judging, $r(168) = -0.48$, $p < 0.001$, *non-reactivity,* $r(168) = -0.54$, $p < 0.001$, *awareness*, $r(168) = -0.44$, $p < 0.001$, and *describing*, $r(168) = -0.37$, $p < 0.001$, were negatively correlated with rumination. However, *observing* was positively correlated with rumination, $r(168) = 0.22$, $p = 0.005$. All correlations were significant with a Bonferroni's adjusted alpha level of 0.008.

Facets of Mindfulness and Sleep Quality

Total PSQI scores were negatively correlated with *non-judging*, $r(168) = -0.37$, $p < 0.001$, *non-reactivity,* $r(168) = -0.36$, $p < 0.001$, *awareness*, $r(168) = -0.39$, $p < 0.001$, and *describing*, $r(168) = -0.39$, $p < 0.001$. All relationships remained significant at a Bonferroni's adjusted alpha level of 0.008.

Mediation Analysis

A mediation analyzing the effect of trait mindfulness on sleep quality, measured by the PSQI, with perceived stress and rumination as mediators and age and gender as covariates was conducted (Figure 1). High levels of mindfulness were negatively associated with perceived stress, $b = -0.37$, $t(166) = -10.50$, $p < 0.001$, and high perceived stress was positively related to poor subjective sleep quality, $b = 0.24$, $t(164) = 5.98$, $p < 0.001$. High levels of mindfulness were also negatively associated with rumination, $b = -0.03$, $t(166) = -8.83$, $p < 0.001$; however, rumination was not significantly associated with subjective sleep quality, $b = 0.19$, $t(164) = 0.46$, $p = 0.64$. The indirect effect through perceived stress was significant, effect size = 0.08, 95% CI [−0.12, −0.06], standardized coefficient $\beta = -0.30$, 95% CI

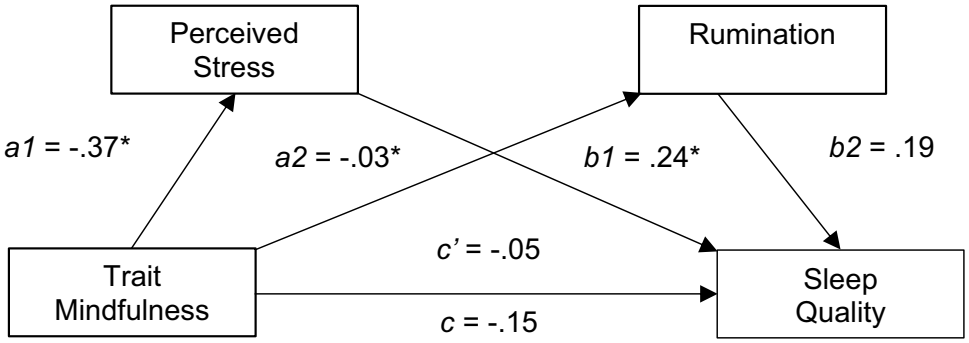

Figure 2 The mediating effect of perceived stress in the relationship between trait mindfulness and subjective sleep quality. The negative association between trait mindfulness and sleep quality was fully mediated by perceived stress.
Note: *$p < 0.001$.

[−0.41, −0.21]. However, the indirect effect through rumination was not, effect size = −0.01, 95% CI [−0.03, 0.02], standardized coefficient β = −0.02, 95% CI [−0.11, 0.07]. This indicates that perceived stress fully mediated the relationship between trait mindfulness and subjective sleep quality. Gender was a significant covariate in the relationship between mindfulness and rumination, $b = 0.35$, $t(166) = 3.03$, $p = 0.0028$. Thus, results confirmed the hypothesis that trait mindfulness is indirectly associated with subjective sleep quality through perceived stress but did not indicate any role of rumination in the relationship between trait mindfulness and subjective sleep quality (see Figure 2).

Secondary Sample Analysis

These results should be regarded as exploratory given the small sample that provided these data.

Sleep diaries: Analyses of the secondary sample revealed an uncorrected positive correlation between diary-based sleep ratings and trait mindfulness, however, none of the other diary-based measures were correlated with trait mindfulness, perceived stress, or rumination (see Table 3).

Actigraphy: There were no significant correlations between perceived stress, rumination, or trait mindfulness, and any of the actigraphy-based measures (see Table 4).

Discussion

This study sought to investigate the interacting effects of trait mindfulness, perceived stress, and rumination in relation to subjective and objective sleep quality. Better sleep quality has been consistently linked to trait mindfulness, however, knowledge around the mediating variables, particularly in young adults, is limited. As expected, high levels of trait

Table 3 Summary of Pearson's and Spearman's Correlations Between Sleep Diary and Questionnaire Measures

Measure (*N* = 21)	1	2	3	4	5	6	7	8
1. Sleep Latency	–							
2. Number of Awakenings	−0.06	–						
3. Sleep Duration	0.20	−0.13	–					
4. Sleep Efficiency	−0.70***	−0.20	0.29	–				
5. Sleep Quality Rating	0.22	0.45*	−0.15	−0.26	–			
6. PSS	0.16	−0.19	0.00	−0.02	−0.34	–		
7. Rumination	0.29	0.00	0.20	−0.28	−0.16	0.55***	–	
8. FFMQ-SF Total	0.10	0.21	−0.25	−0.24	0.41*	−0.63***	−0.55***	–

Notes: *$p < 0.05$, ***$p < 0.001$. PSS= Perceived Stress Scale,[34] Rumination measured by the Rumination Reflection Questionnaire,[46] FFMQ-SF = Five Facets of Mindfulness Questionnaire Short Form.[65]

Table 4 Summary of Pearson's and Spearman's Correlations Between Actigraphy and Questionnaire Measures

Measure (*N* = 23)	1	2	3	4	5	6
1. Sleep Duration	–					
2. Number of Activity Periods	−0.12	–				
3. Sleep Efficiency	0.73***	−0.08	–			
4. PSS	−0.36	−0.08	−0.39	–		
5. Rumination	−0.20	−0.05	−0.33	0.55***	–	
6. FFMQ-SF Total	0.00	−0.28	0.20	−0.63***	−0.55***	–

Notes: ***p <0.001. PSS= Perceived Stress Scale,[34] Rumination measured by the Rumination Reflection Questionnaire,[46] FFMQ-SF = Five Facets of Mindfulness Questionnaire Short Form.[65]

mindfulness were associated with low levels of perceived stress, rumination, and better subjective sleep quality (measured by the PSQI). Both rumination and perceived stress were associated with poorer subjective sleep quality on the PSQI. Importantly, perceived stress was found to fully mediate the relationship between trait mindfulness and subjective sleep quality; however, no mediating role was found for rumination. Other than the positive (uncorrected) association between trait mindfulness and diary-based sleep ratings, none of the sleep diary- or actigraphy-based measures were related to any of the other variables, but these results should be regarded as preliminary given the small secondary sample who provided these data. We also explored the effects of specific mindfulness facets.

The negative association between trait mindfulness and rumination is consistent with previous studies and the fact that they are theoretically opposed constructs.[60] The Monitor and Acceptance Theory suggests that mindful individuals are more likely to disengage from ruminative thoughts, resulting first from *observing*, followed by *non-judging* and *non-reactivity*, thus reducing stress and stress-related outcomes.[19,60,61] While heightened *observing* of thoughts is a characteristic of high ruminators (a positive association with rumination was found here), the other facets (including *non-judging* and *non-reactivity*) were negatively associated with rumination, highlighting the importance of these other factors for counteracting ruminative tendencies. In turn, rumination was negatively related to subjective sleep quality, as is well demonstrated in the literature.[47] The heightened cognitive and physiological arousal caused by rumination is thought to underlie this.

Trait mindfulness, and the facets of *non-judging, non-reactivity, awareness*, and *describing*, were negatively correlated with perceived stress in the present study. Higher trait mindfulness is consistently associated with lower perceived stress,[42,69,70] although fewer studies have explored the effects of individual facets. Here, *observing* was not associated with perceived stress. This finding is of value as it provides support for previous studies that found likewise. Both Ballantyne et al and McBride et al found that while the other facets were linked to reduced perceived stress, *observing* was associated with higher stress and physical symptoms of stress.[71,72] Again, in relation to Lindsay & Creswell's Monitor and Acceptance Theory, it seems that attention monitoring alone is insufficient to reduce stress and might in fact be detrimental.[61] Without the ability to respond to present moment experience in a *non-judgmental*/*non-reactive* way, higher levels of *observing* may lead to distress and maladaptive coping.[73] Other negative effects of *observing* have been noted, eg the meta-analysis by Sala et al found that higher *observing* was associated with higher substance use.[16]

As expected, perceived stress and trait mindfulness were inversely related to subjective sleep quality. Sala et al found that acting with *awareness* and *describing* were the most important facets regarding sleep quality while *observing* was not related, possibly due to higher engagement in health risk behaviors, eg substance use.[16] Here, *non-judging, non-reactivity, awareness*, and *describing* were seen to be of benefit, while *observing* had no relationship with sleep quality. In other studies, in undergraduate samples, acting with *awareness* and *non-judgement* were associated with higher sleep quality on the PSQI, while *observing* had negative effects.[18,74] Recent work in an undergraduate student sample found that the associations between *observing* and sleep health were moderated by *non-reactivity*: *observing* was associated with worse sleep at lower levels of *non-reactivity*, but better sleep health at higher levels of *non-reactivity*.[28]

Trait mindfulness is known to be a buffer against psychological distress and perceived stress, which in turn impacts health behaviors such as sleep quality.[19–21] Simione et al found that, in a general adult sample, mindfulness was negatively

related to stress and this effect fully mediated the positive relationship between mindfulness and sleep quality.[21] Lau et al and Roberts & Danoff-Burg found a partial mediation effect in undergraduate samples.[19,20] The present study sought to clarify this relationship, focusing on young adults, and by including rumination as an additional mediator. This is of value given the well-characterized relationships between mindfulness and rumination, and between rumination and sleep. Thus, reduced rumination is a potential mechanism through which mindfulness could be linked to better sleep. This is the first study to test such a model. Results showed that the relationship between trait mindfulness and subjective sleep quality is fully mediated by perceived stress. However, no mediating effect of rumination was observed.

This confirms that perceived stress plays a key role in the relationship. Thus, mindfulness appears to diminish the negative effects of stress, particularly in high-stress populations such as students, and when there is a direct impact of stress on the health outcome, eg sleep.[44] Trait mindfulness and mindfulness-based training have been shown to influence affect regulation, and mindfulness-based training has been shown to alter stress reactivity; this is thought to impact health outcomes by reducing physiological stress responses.[44,75,76] These findings provide valuable insight into the mechanisms linking trait mindfulness to sleep quality and are of high relevance to young adults, particularly students who often report poor sleep and high levels of stress;[77] stress appears to be the key mechanism and mediating factor (rather than rumination) in the relationship. This finding informs future research and intervention designs: it suggests that interventions should emphasize stress reduction within MBIs, for improving sleep quality among young adults. This is crucial given the high prevalence of sleep issues reported among young adult populations (as seen here and in previous research) and the important consequences of this for young adults' daytime functioning, as well as longer-term physical and mental health outcomes.

A small secondary sample contributed objective sleep measures, allowing us to conduct exploratory analyses on these. This is of value given that the overwhelming majority of previous work has used subjective sleep measures only. Comparative studies in the sleep literature indicate that participants are often inaccurate when estimating their sleep duration and number of nighttime awakenings,[13] with low correlations between self-reported sleep and actigraphy data.[78] Here, the objective actigraphy-based measures were not associated with perceived stress, rumination, or trait mindfulness. This accords with a recent meta-analysis by Clancy et al,[79] showing that links between rumination and sleep quality are much stronger for subjective, compared to objective measures of sleep quality. High rumination might create a cognitive bias for perceiving and reporting poor sleep quality, as theorized by Harvey et al.[80] Similar perception biases could serve to partially explain the relationships between stress, mindfulness, and subjective sleep quality as well. The lack of relationships with the objective sleep measures employed here would support this, but it is important to acknowledge that the non-significant findings may be due to the secondary sample being small and underpowered, potentially resulting in a Type II error. Thus, replication of the present study is required. A recent study in undergraduates derived a composite "sleep health" measure that combined actigraphy data with subjective sleep ratings; this measure correlated with higher mindfulness scores in *awareness*, *non-reactivity*, and *non-judgment*,[28] it would be of interest to explore whether this was also the case if only the objective ratings were included.

A weakness of the current study is that we relied on subjective measures of the traits under investigation, making the study susceptible to various biases including social desirability bias, demand characteristics, and order effects. The focus on trait-like characteristics is also a limitation. Pre-sleep rumination has the strongest negative impact on sleep;[52] hence, future research should aim to employ measures of state rumination specifically assessing pre-sleep rumination, eg via experience sampling, to confirm the current findings.

Additionally, the study sample was not randomly selected and was recruited from one university, potentially skewing the findings, and limiting their generalizability. The sample was also predominantly female, and the small number of males prevented us from studying potential gender-specific effects. Although a female-dominated sample is not uncommon in the literature, future work should aim to explore the effects in a larger sample that has a more even gender balance.

Finally, a longitudinal design would have allowed inferences regarding causality. In the mediation analysis, trait mindfulness was input as the independent variable, and sleep quality as the dependent variable: this was based on evidence showing reductions in rumination and perceived stress, and improvements in sleep quality, following MBIs.[81–84] Still, due to the cross-sectional nature, the findings from this study are strictly correlational and the direction of causality cannot be inferred.

Conclusion

Overall, findings from this study indicate that perceived stress, rather than rumination, is a key mediating variable linking trait mindfulness to better subjective sleep quality in young adults. This adds important mechanistic detail to the literature, and the current findings have practical importance for addressing poor sleep quality, which is highly prevalent among young adults. Results provide a strong rationale for considering MBIs as an alternative to pharmacological treatment, as they have high efficacy and adherence, and no adverse side effects.[13] Further, the findings also inform the design of MBIs, indicating that they should focus on reducing perceived stress, to optimize therapeutic outcomes.

Abbreviations

CBT-I, Cognitive Behavioral Therapy for Insomnia; FFMQ, Five Facets of Mindfulness Questionnaire; FFMQ-SF, Five Facets of Mindfulness Questionnaire Short Form; MBIs, mindfulness-based interventions; NICE, National Institute for Health and Care Excellence; PSS, Perceived Stress Scale; PSQI, Pittsburgh Sleep Quality Index; RRQ, Rumination-Reflection Questionnaire.

Ethics and Consent Statements

This study complies with the Declaration of Helsinki. Prior to data collection, favorable ethical opinion was obtained from the London-Surrey NHS Research Ethics Committee and the University of Surrey Ethics Committee. Participants signed informed consent prior to their participation in the study, including for the publication of their data.

Disclosure

The authors have no competing interests to declare that are relevant to the content of this article.

References

1. Calem M, Bisla J, Begum A, et al. Increased prevalence of insomnia and changes in hypnotics use in England over 15 years: analysis of the 1993, 2000, and 2007 National Psychiatric Morbidity Surveys. *Sleep*. 2012;35(3):377–384. doi:10.5665/sleep.1700
2. Lane J, Jones S, Dashti H, et al. Biological and clinical insights from genetics of insomnia symptoms. *Nat Genet*. 2019;51(1):387–393. doi:10.1038/s41588-019-0361-7
3. Norbury R, Evans S. Time to think: subjective sleep quality, trait anxiety and university start time. *Psychiatry Res*. 2018;271:214–219. doi:10.1016/j.psychres.2018.11.054
4. Harvey AG. Insomnia: symptom or diagnosis? *Clin Psychol Rev*. 2001a;21(7):1037–1059. doi:10.1016/s0272-7358(00)00083-0
5. Jansson M, Linton SJ. Psychological mechanisms in the maintenance of insomnia: arousal, distress, and sleep-related beliefs. *Behav Res Ther*. 2007;45(3):511–521. doi:10.1016/j.brat.2006.04.003
6. Van Veen M, Karsten J, Verkes R, Lancel M. Sleep quality is associated with aggression in forensic psychiatric patients, independent of general psychopathology. *J Forensic Psychiatry Psychol*. 2020;31(5):699–713. doi:10.1080/14789949.2020.1785526
7. Irwin M. Why sleep is important for health: a psychoneuroimmunology perspective. *Annu Rev Psychol*. 2014;66(1):143–172. doi:10.1146/annurev-psych-010213-115205
8. Ogilvie R, Patel S. The epidemiology of sleep and diabetes. *Curr Diab Rep*. 2018;18(10). doi:10.1007/s11892-018-1055-8
9. National Institute for Health and Care Excellence. Sleepio to treat insomnia and insomnia symptoms; 2022. Available from: https://www.nice.org.uk/guidance/mtg70. Accessed September 26, 2023.
10. Morin CM, Vallières A, Guay B, et al. Cognitive-behavior therapy, singly and combined with medication, or persistent insomnia: acute and maintenance therapeutic effects. *JAMA*. 2009;301(19):2005. doi:10.1001/jama.2009.682
11. National Institute for Health and Care Excellence (NICE). Guidance on the use of zaleplon, zolpidem and zopiclone for the short-term management of insomnia; 2004. Available from: https://www.nice.org.uk/guidance/ta77. Accessed January 15, 2023.
12. Riemann D, Baglioni C, Bassetti C, et al. European guideline for the diagnosis and treatment of insomnia. *J Sleep Res*. 2017;26(6):675–700. doi:10.1111/jsr.12594
13. Kanen J, Nazir R, Sedky K, Pradhan B. The effects of mindfulness-based interventions on sleep disturbance: a meta-analysis. *Adolesc Psychiatry*. 2015;5(2):105–115. doi:10.2174/2210676605666150311222928
14. Ong JC, Kalmbach DA. Mindfulness as an adjunct or alternative to CBT-I. *Sleep Med Clin*. 2023;18(1):59–71. doi:10.1016/j.jsmc.2022.09.002
15. Kabat-Zinn J. *Full Catastrophe Living: Using the Wisdom of Your Body and Mind to Face Stress, Pain, and Illness*. New York: Dell Publishing; 1990.
16. Sala M, Rochefort C, Lui PP, Baldwin AS. Trait mindfulness and health behaviours: a meta-analysis. *Health Psychol Rev*. 2020;14(3):345–393. doi:10.1080/17437199.2019.1650290
17. Howell AJ, Digdon NL, Buro K, Sheptycki AR. Relations among mindfulness, well-being, and sleep. *Pers Individ Dif*. 2008;45(8):773–777. doi:10.1016/j.paid.2008.08.005
18. Murphy MJ, Mermelstein LC, Edwards KM, Gidycz CA. The benefits of dispositional mindfulness in physical health: a longitudinal study of female college students. *J Am Coll Health*. 2012;60(5):341–348. doi:10.1080/07448481.2011.629260

19. Lau W, Leung M, Wing Y, Lee T. Potential mechanisms of mindfulness in improving sleep and distress. *Mindfulness*. 2017;9(2):547–555. doi:10.1007/s12671-017-0796-9
20. Roberts KC, Danoff-Burg S. Mindfulness and health behaviors: is paying attention good for you? *J Am Coll Health*. 2010;59(3):165–173. doi:10.1080/07448481.2010.484452
21. Simione L, Raffone A, Mirolli M. Stress as the missing link between mindfulness, sleep quality, and well-being: a cross-sectional study. *Mindfulness*. 2019;11(2):439–451. doi:10.1007/s12671-019-01255-y
22. Caldwell K, Harrison M, Adams M, et al. Developing mindfulness in college students through movement-based courses: effects on self-regulatory self-efficacy, mood, stress, and sleep quality. *J Am Coll Health*. 2010;58(5):433–442. doi:10.1080/07448480903540481
23. Adam K, Tomeny M, Oswald I. Physiological and psychological differences between good and poor sleepers. *J Psychiatr Res*. 1986;20 (4):301–316. doi:10.1016/0022-3956(86)90033-6
24. Biddle D, Robillard R, Hermens DF, Hickie I, Glozier N. Accuracy of self-reported sleep parameters compared with actigraphy in young people with mental ill-health. *Sleep Health*. 2015;1(3):214–220. doi:10.1016/j.sleh.2015.07.006
25. Baer RA, Smith GT, Hopkins J, Krietemeyer J, Toney L. Using self-report assessment Methods to explore facets of mindfulness. *Assessment*. 2006;13(1):27–45. doi:10.1177/1073191105283504
26. Tomlinson ER, Yousaf O, Vittersø AD, Jones L. Dispositional mindfulness and psychological health: a systematic review. *Mindfulness*. 2018;9 (1):23–43. doi:10.1007/s12671-017-0762-6
27. Garland SN, Campbell T, Samuels C, Carlson LE. Dispositional mindfulness, insomnia, sleep quality and dysfunctional sleep beliefs in post-treatment cancer patients. *Pers Individ Dif*. 2013;55(3):306–311. doi:10.1016/j.paid.2013.03.003
28. Talley G, Shelley-Tremblay J. The relationship between mindfulness and sleep quality is mediated by emotion regulation. *Psychiatry Int*. 2020;1 (2):42–66. doi:10.3390/psychiatryint1020007
29. Brown KW, Ryan RM. The benefits of being present: mindfulness and its role in psychological well-being. *J Pers Soc Psychol*. 2003;84 (4):822–848. doi:10.1037/0022-3514.84.4.822
30. Ong JC, Ulmer CS, Manber R. Improving sleep with mindfulness and acceptance: a metacognitive model of insomnia. *Behav Res Ther*. 2012;50 (11):651–660. doi:10.1016/j.brat.2012.08.001
31. Alsaggaf MA, Wali SO, Merdad RA, Merdad LA. Sleep quantity, quality, and insomnia symptoms of medical students during clinical years: relationship with stress and academic performance. *Saudi Med J*. 2016;37(2):173–182. doi:10.15537/smj.2016.2.14288
32. Lin S, Liao W, Chen M, Fan J. The impact of shift work on nurses' job stress, sleep quality and self-perceived health status. *J Nurs Manag*. 2014;22 (5):604–612. doi:10.1111/jonm.12020
33. Oh WO, Im Y, Suk MH. The mediating effect of sleep satisfaction on the relationship between stress and perceived health of adolescents suffering atopic disease: secondary analysis of data from the 2013 9th Korea Youth Risk Behaviour Web-based Survey. *Int J Nurs Stud*. 2016;63:132–138. doi:10.1016/j.ijnurstu.2016.08.012
34. Cohen S, Williamson G. Perceived stress in a probability sample of the United States. In: *The Social Psychology of Health*. Sage Publications, Inc; 1988:31–67.
35. Garde A, Albertsen K, Persson R, Hansen Å, Rugulies R. Bi-directional associations between psychological arousal, cortisol, and sleep. *Behav Sleep Med*. 2012;10(1):28–40. doi:10.1080/15402002.2012.636272
36. Nollet M, Wisden W, Franks N. Sleep deprivation and stress: a reciprocal relationship. *Interface Focus*. 2020;10(3). doi:10.1098/rsfs.2019.0092
37. Akerstedt T, Garefelt J, Richter A, Kecklund G. Work and sleep— a prospective study of psychosocial work factors, physical work factors, and work scheduling. *Sleep*. 2015;38:1129–1136. doi:10.5665/sleep.4828
38. Charles L, Slaven J, Mnatzakanova A, et al. Association of perceived stress with sleep duration and sleep quality in police officers. *Int J of Emerg Ment Health*. 2011;13(4):229–241.
39. Goldberg Z, Thomas K, Lipinska G. Bedtime stress increases sleep latency and impairs next-day prospective memory performance. *Front Neurosci*. 2020;14. doi:10.3389/fnins.2020.00756
40. Massar S, Liu J, Mohammad N, Chee M. Poor habitual sleep efficiency is associated with increased cardiovascular and cortisol stress reactivity in men. *Psychoneuroendocrinology*. 2017;81:151–156. doi:10.1016/j.psyneuen.2017.04.013
41. Yap Y, Slavish D, Taylor D, Bei B, Wiley J. Bi-directional relations between stress and self-reported and actigraphy-assessed sleep: a daily intensive longitudinal study. *Sleep*. 2020;43(3). doi:10.1093/sleep/zsz250
42. Brisbon N, Lachman M. Dispositional mindfulness and memory problems: the role of perceived stress and sleep quality. *Mindfulness*. 2016;8 (2):379–386. doi:10.1007/s12671-016-0607-8
43. Cohen S, Wills TA. Stress, social support, and the buffering hypothesis. *Psychol Bull*. 1985;98(2):310–357. doi:10.1037/0033-2909.98.2.310
44. Creswell JD, Lindsay EK. How does mindfulness training affect health? A mindfulness stress buffering account. *Curr Dir Psychol Sci*. 2014;23 (6):401–407. doi:10.1177/0963721414547415
45. van der Riet P, Rossiter R, Kirby D, Dluzewska T, Harmon C. Piloting a stress management and mindfulness program for undergraduate nursing students: student feedback and lessons learned. *Nurse Educ Today*. 2015;35(1):44–49. doi:10.1016/j.nedt.2014.05.003
46. Trapnell PD, Campbell JD. Private self-consciousness and the five-factor model of personality: distinguishing rumination from reflection. *J Pers Soc Psychol*. 1999;76(2):284.
47. Gregory A, Willis T, Wiggs L, Harvey A. Presleep arousal and sleep disturbances in children. *Sleep*. 2008;31(12):1745–1747. doi:10.1093/sleep/31.12.1745
48. Morin CM, Rodrigue S, Ivers H. Role of stress, arousal, and coping skills in primary insomnia. *Psychosomatic Med*. 2003;65:259–267. doi:10.1097/01.psy.0000030391.09558.a3
49. Winzeler K, Voellmin A, Schafer V, et al. Daily stress, presleep arousal, and sleep in healthy young women: a daily life computerized sleep diary and actigraphy study. *Sleep Med*. 2014;15:359–366. doi:10.1016/j.sleep.2013.09.027
50. Tousignant O, Taylor N, Suvak M, Fireman G. Effects of rumination and worry on sleep. *Behavior Therapy*. 2019;50(3):558–570. doi:10.1016/j.beth.2018.09.005
51. Smith JM, Alloy LB. A roadmap to rumination: a review of the definition, assessment, and conceptualization of this multifaceted construct. *Clin Psychol Rev*. 2009;29(2):116–128. doi:10.1016/j.cpr.2008.10.003

52. Guastella AJ, Moulds ML. The impact of rumination on sleep quality following a stressful life event. *Pers Individ Dif*. 2007;42(6):1151–1162. doi:10.1016/j.paid.2006.04.028
53. Greenfield M. *The Effect of Sleep Quality on Daily Rumination: Implications for the Sleep-Emotion Relationship* [Dissertation]. Washington: American University; 2016.
54. Pillai V, Steenburg L, Ciesla J, Roth T, Drake C. A seven day actigraphy-based study of rumination and sleep disturbance among young adults with depressive symptoms. *J Psychosom Res*. 2014;77(1):70–75. doi:10.1016/j.jpsychores.2014.05.004
55. Thomsen D, Yung Mehlsen M, Christensen S, Zachariae R. Rumination – relationship with negative mood and sleep quality. *Pers Individ Dif*. 2003;34(7):1293–1301. doi:10.1016/s0191-8869(02)00120-4
56. Carney C, Harris A, Moss T, Edinger J. Distinguishing rumination from worry in clinical insomnia. *Behav Res Ther*. 2010;48(6):540–546. doi:10.1016/j.brat.2010.03.004
57. Wang Y, Yip T. Sleep Facilitates Coping: moderated mediation of daily sleep, ethnic/racial discrimination, stress responses, and adolescent well-being. *Child Dev*. 2020;91(4). doi:10.1111/cdev.13324
58. Yeh Z, Wung S, Lin C. Pre-sleep arousal as a mediator of relationships among worry, rumination, and sleep quality. *Int J Cogn Ther*. 2015;8 (1):21–34. doi:10.1521/ijct.2015.8.1.21
59. Tutek J. *Clarifying the Contributions of Worry and Rumination in Predicting Subjective SLeep Outcomes*. [Dissertation]. Tuscaloosa: University of Alabama; 2020.
60. Raes F, Williams J. The Relationship between mindfulness and uncontrollability of ruminative thinking. *Mindfulness*. 2010;1(4):199–203. doi:10.1007/s12671-010-0021-6
61. Lindsay EK, Creswell JD. Mechanisms of mindfulness training: monitor and Acceptance Theory (MAT). *Clin Psychol Rev*. 2016;51:48–59. doi:10.1016/j.cpr.2016.10.011
62. Liu Q, Zhou Z, Yang X, Kong F, Sun X, Fan C. Mindfulness and sleep quality in adolescents: analysis of rumination as a mediator and self-control as a moderator. *Pers Individ Dif*. 2018;122:171–176. doi:10.1016/j.paid.2017.10.031
63. Buysse DJ, Reynolds CF, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *J Psychiatr Res*. 1989;28(2):193. doi:10.1016/0165-1781(89)90047-4
64. Carney C, Buysse D, Ancoli-Israel S, et al. The Consensus Sleep Diary: standardizing prospective sleep self-monitoring. *Sleep*. 2012;35 (2):287–302. doi:10.5665/sleep.1642
65. Bohlmeijer E, ten Klooster PM, Fledderus M, Veehof M, Baer R. Psychometric properties of the Five Facet Mindfulness Questionnaire in depressed adults and development of a short form. *Assessment*. 2011;18(3):308–320. doi:10.1177/1073191111408231
66. Field A. *Discovering Statistics Using IBM® SPSS Statistics and Sex and Drugs and Rock 'N' Roll*. 4th ed. Chicago: Sage; 2013.
67. Tabachnick BG, Fidell LS. *Using Multivariate Statistics*. 5th ed. New York: Pearson Education Inc; 2007.
68. Reed D, Sacco W. Measuring sleep efficiency: what should the denominator be? *J Clin Sleep Med*. 2016;12(2):263–266.
69. Atanes ACM, Andreoni S, Hirayama MS, et al. Mindfulness, perceived stress, and subjective well-being: a correlational study in primary care health professionals. *BMC Complement Altern Med*. 2015;15(303). doi:10.1186/s12906-015-0823-0
70. Hepburn S, Carroll A, McCuaig L. The relationship between mindful attention awareness, perceived stress and subjective wellbeing. *Int J Environ Res Public Health*. 2021;18(23). doi:10.3390/2Fijerph182312290
71. Ballantyne C, Hunter PV, Potter GK, Myge I. Mindfulness and perceptions of physical health: the mediating role of perceived stress. *Can J Behav Sci*. 2021;53(3):321–327. doi:10.1037/cbs0000255
72. McBride EE, Chin GR, Clauser KS, Greeson JM. Perceived stress mediates the relationship between trait mindfulness and physical symptoms of stress: a replication study using structural equation modeling. *Mindfulness*. 2022;13:1923–1930. doi:10.1007/s12671-022-01928-1
73. Eisenlohr TA, Walsh EC, Charnigo RJ, Lynam DR, Baer RA. The "what" and the "how" of dispositional mindfulness: using interactions among subscales of the Five-Facet Mindfulness Questionnaire to understand its relation to substance use. *Assessment*. 2012;19(3):276–286. doi:10.1177/1073191112446658
74. Xie EB, Sedov ID, Sanguino H, Freeman M, Kumari J, Tomfohr-Madsen L. Trait mindfulness and sleep: interactions between observing and nonreactivity in the association with sleep health. *Health Psychol Open*. 2023;10(1). doi:10.1177/20551029221149282
75. Creswell JD, Way BM, Eisenberger NI, Lieberman MD. Neural correlates of dispositional mindfulness during affect labelling. *Psychosomatic Med*. 2007;69:560–565. doi:10.1097/PSY.0b013e318056171f
76. Modinos G, Ormel J, Aleman A. Individual differences in dispositional mindfulness and brain activity involved in reappraisal of emotion. *Soc Cogn Affect Neurosci*. 2010;5(4):369–377. doi:10.1093/scan/nsq006
77. Kwan MY, Arbour-Nicitopoulos KP, Duku E, Faulkner G. Patterns of multiple health risk-behaviours in university students and their association with mental health: application of latent class analysis. *Health Promot Chronic Dis Prev Can*. 2016;36(8). doi:10.24095/hpcdp.36.8.03
78. Girschik J, Fritschi L, Heyworth J, Waters F. Validation of self-reported sleep against actigraphy. *J Epidemiol*. 2012;22(5):462–468. doi:10.2188/2Fjea.JE20120012
79. Clancy F, Prestwich A, Caperon L, Tsipa A, O'Connor DB. The association between worry and rumination with sleep in non-clinical populations: a systematic review and meta-analysis. *Health Psychol Rev*. 2020;14(4):427–448. doi:10.1080/17437199.2019.1700819
80. Harvey A. A cognitive model of insomnia. *Behav Res Ther*. 2002;40(8):869–893. doi:10.1016/s0005-7967(01)00061-4
81. Campbell TS, Labelle LE, Bacon SL, Faris P, Carlson LE. Impact of mindfulness-based stress reduction (MBSR) on attention, rumination and resting blood pressure in women with cancer: a waitlist-controlled study. *J Behav Med*. 2012;35(3):262–271. doi:10.1007/s10865-011-9357-1
82. Carlson L, Garland S. Impact of mindfulness-based stress reduction (MBSR) on sleep, mood, stress and fatigue symptoms in cancer outpatients. *Int J Behav Med*. 2005;12(4):278–285. doi:10.1207/s15327558ijbm1204_9
83. Epel E, Daubenmier J, Moskowitz J, Folkman S, Blackburn E. Can meditation slow rate of cellular aging? Cognitive stress, mindfulness, and telomeres. *Ann N Y Acad Sci*. 2009;1172(1):34–53. doi:10.1111/j.1749-6632.2009.04414.x
84. Hassirim Z, Lim E, Lo J, Lim J. 0145 Pre-sleep cognitive arousal decreases following a 4-Week introductory mindfulness course. *Sleep*. 2020;43 (Suppl 1):A57–A58. doi:10.1093/sleep/zsaa056.143