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Relationship between neuroticism and sleep quality among asthma patients: the mediation effect of mindfulness

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Abstract

Objective The aims of this study were to investigate the prevalence of sleep disturbance; to validate the associations between neuroticism, mindfulness, and sleep quality; and to further examine whether mindfulness mediates the relationship between neuroticism and sleep quality among asthma patients.

Methods This study was conducted with 193 asthma patients from outpatient clinics. They completed questionnaires including the neuroticism subscale of the Big Five Inventory (BFI), the Pittsburgh Sleep Quality Index (PSQI), and the Mindful Attention Awareness Scale (MAAS). Structural equation model was used to analyze the relationships among neuroticism, mindfulness, and sleep quality, with mindfulness as a mediator.

Results The mean global PSQI score was 7.57 ($SD = 3.25$), and 69.9% of asthma patients reported poor sleep quality (cutoff score > 5). Structural equation model analysis showed that neuroticism was significantly associated with global PSQI scores ($\beta = 0.198$, $P = 0.006$), and mindfulness ($\beta = -0.408$, $P < 0.001$), respectively; mindfulness was associated with global PSQI scores ($\beta = -0.250$, $P = 0.006$). Furthermore, mindfulness mediated the relationship between neuroticism and global PSQI scores, in which the mediation effect was 0.102 (-0.408×-0.250), and the bootstrapped 95% CI did not include zero (0.032, 0.208, $P = 0.021$).

Conclusions Sleep disturbance is a serious health concern among asthma patients. This study illuminated the latent mediating mechanism of mindfulness on neuroticism and sleep quality, and implied that intervention and prevention programs on mindfulness might be beneficial in improving sleep quality in asthma patients.

Keywords Asthma patients · Sleep quality · Neuroticism · Mindfulness · Mediation

Introduction

Asthma is a common chronic respiratory disorder suffered by approximately 300 million individuals worldwide [1], of which 20 million are in China. Owing to the characteristics of respiratory symptoms (e.g., dyspnea, wheezing, chest tightness, and coughing) [2] and nocturnal exacerbation of asthma [3], it is difficult for asthma patients to initiate and maintain sleep, frequently leading to sleep disturbances such as prolonged sleep latency and sleep fragmentation [4]. The prevalence of poor sleep was 79% among asthma patients in a large prospective clinical trial [5]. Campos et al. also found 80.49% of patients with asthma developed problematic sleep [6]. Furthermore, disturbed sleep in asthma patients has a negative effect on daytime performance, immune function, and lung function [4, 7, 8], which in turn could cause recurrence and exacerbate asthma severity [9]. Thus, greater attention to sleep quality is of paramount importance for asthma patients.

Besides disease-related factors [10–12], sleep quality was also influenced by psychological factors. Based on Spielman and Glovinsky's 3P Model of insomnia, predisposing factors, including personality traits, are key predictors of sleep problems [13]. Neuroticism, a prominent personality type [14], has demonstrated an appreciable association with sleep quality in non-asthmatic samples [15, 16]. The plausible explanation is that neuroticism confers difficulty with regulating emotions, increasing one's emotionality conflicts (anxiety, worry and

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depression), and disrupting their sleep by increasing sleep onset latency, wakefulness after sleep onset, and number of awakenings from rapid eye movement sleep [16, 17]. A prospective cohort study showed that neuroticism was the only personality trait which was predictive of asthma [18], and high neuroticism had a threefold elevated risk of developing asthma compared to low neuroticism in adults [19]. However, there is a paucity of studies that tried to understand the relationship between neuroticism and sleep quality in asthma patients. To fill in the study gaps, more research should be conducted to address the issue. What is noteworthy is that personality is a stable trait and difficult to change, especially in later adulthood. Therefore, targeting core traits of neuroticism may not be effective or at least long-lasting [20]. In addition, the mechanism between neuroticism and sleep is not yet entirely clear. Thus, the current study seeks to identify malleable sources in explaining the association between neuroticism and sleep quality among asthma patients.

Mindfulness, as a cognitive style [21], is defined as the awareness that emerges through paying attention on purpose, in the present moment, and nonjudgmentally to the unfolding of experience moment by moment [22]. Correlational studies revealed that mindfulness was conducive to several sleep-related aspects (e.g., lower pre-sleep arousal, decreased daytime somnolence, and shorter sleep latency) [23, 24]. In terms of Lundh's cognitive mechanisms of sleep problems, mindfulness is an essential component in treating sleep problems. That is, mindfulness is associated with better sleep by maintaining good regulation of cognitive processes [25]. Ong proved that mindfulness could shift mental processes to acceptance of insomnia experience via increasing awareness of the mental and physical states in insomnia sufferers [26]. Although researchers have demonstrated the relationship between mindfulness and sleep [27, 28], it cannot be generalized to the asthma population. Therefore, the present study intends to determine if the associations hold true for a sample of asthma patients. What's more, neuroticism is negatively associated with mindfulness in general population [29–31]. It is possible that neurotic individuals pay more attention to negative emotionality and personal feelings, and cannot maintain awareness of their immediate experience [14], which attenuate the level of mindfulness. Given the findings of the above literature, we speculated that neuroticism not only has a direct effect on sleep quality, but also can exert its effect on sleep quality through mindfulness. However, to our knowledge, no published study has examined this potential mediating mechanism among asthma patients. Importantly, as a trait-like psychological construct, mindfulness can be enhanced through meditation or mindfulness training [32, 33], which implies that improving mindfulness might be an effective intervention strategy for sleep quality in neurotic asthma patients.

Hence, the primary aims of this study are (1) to delineate the prevalence of sleep disturbance among asthma patients; (2) to identify the relationships between neuroticism, mindfulness, and sleep quality; and (3) to explore the mediating effect of mindfulness on neuroticism and sleep quality. The clinical implications of these findings could contribute to improving sleep quality in patients with asthma by practicing mindfulness techniques for individuals susceptible to sleep disturbance.

Material and methods

Participants

A cross-sectional design was adopted in this study. The participants were recruited from the asthmatic outpatient departments of three public hospitals in Shandong Province, China. Inclusion criteria were age ≥ 18 years, diagnosis of asthma (including cough variant asthma, dyspnea asthma, and chest tightness variant asthma) and no other pulmonary or somatic disease conditions, ability to read and understand Chinese, appropriate cognitive ability for the study, and willingness to participate. A total of 240 individuals were invited to take part in this study. Of these, 38 refused participation, 9 were removed due to incomplete survey answers, and a final total of 193 patients were included in the analysis. Participants were requested to independently complete the survey, which was retrieved on the spot. The study was approved by the authors' institutes, and all participants gave informed consent. The socio-demographic information included gender, age, marital status, residence, and body mass index (BMI). Disease-related data contained medical history, attack times, and pulmonary function and complications. Medical history referred to time since asthma diagnosis, which was categorized as a binary variable by median medical history (5 year). Attack times was defined as the number of attacks per year, which included daytime and nighttime asthma attacks, and categorized as ≤ 2 times/year and > 2 times/year. Complications was considered a binary variable ("no" or "yes," including pneumothorax, pneumomediastinum, atelectasis, chronic obstructive pulmonary disease, and bronchiectasis) (Table 1).

Measures

Sleep quality

The Pittsburgh Sleep Quality Index (PSQI) is an instrument that measures individuals' subjective sleep quality over the prior month [34]. The tool is a widely used and well-validated 19-item self-administered scale that includes seven components: subjective sleep quality (S1) is a subjective assessment of sleep quality; sleep latency (S2) is the amount of time spent lying in bed before sleep; sleep duration (S3) is the amount of time spent sleeping each night; habitual sleep

Table 1 Socio-demographic and disease-related information and differences in sleep quality

Variables	*N* (%)	PSQI (*M* ± SD)	*t*/*F*	*P*
Gender			− 2.025	0.044
Male	97 (50.3)	7.10 ± 3.07		
Female	96 (49.7)	8.04 ± 3.36		
Age			6.118	0.003
≤ 40 years	58 (30.1)	6.41 ± 2.91		
40~60 years	80 (41.5)	7.83 ± 3.49		
> 60 years	55 (28.4)	8.42 ± 2.90		
Marital status			1.881	0.062
Married	178 (92.2)	7.70 ± 3.24		
Not Married	15 (7.8)	6.07 ± 2.99		
Residence			0.344	0.732
City	104 (53.9)	7.64 ± 3.29		
Country	89 (46.1)	7.48 ± 3.21		
Body mass index			0.629	0.597
< 18.5 kg/m^2	11 (5.7)	6.91 ± 3.59		
18.5~24.99 kg/m^2	125 (64.8)	7.55 ± 3.09		
25~28 kg/m^2	37 (19.2)	7.38 ± 3.05		
> 28 kg/m^2	20 (10.4)	8.40 ± 4.30		
Medical history			− 4.813	< 0.001
≤ 5 years	111 (57.5)	6.65 ± 3.00		
> 5 years	82 (42.5)	8.82 ± 3.16		
Attack times			− 3.371	0.001
≤ 2 times/year	126 (65.3)	7.03 ± 3.30		
> 2 times/year	67 (34.7)	8.58 ± 2.89		
Pulmonary function			1.507	0.224
Normal	39 (20.2)	6.92 ± 3.86		
Mild	93 (48.2)	7.52 ± 3.18		
Moderate or severe	61 (31.6)	8.07 ± 2.87		
Complications or not			− 2.322	0.022
No	132 (68.4)	7.18 ± 3.01		
Yes	61 (31.6)	8.41 ± 3.59		

PSQI, Pittsburgh Sleep Quality Index; *M* ± *SDs*, mean ± standard deviations. The *P* values were tested using the *t* test or ANOVA. Complications refer to pneumothorax, pneumomediastinum, atelectasis, chronic obstructive pulmonary disease, and bronchiectasis

efficiency (S4) is a calculation of the amount of time spent sleeping compared with the amount of time spent lying in bed; sleep disturbances (S5) rates the frequency of experiencing barriers to sleep, such as early waking or bad dreams; use of sleeping medications (S6) refers to use of prescription or non-prescription sleep aids; and daytime dysfunction (S7) refers to common daytime consequences of poor sleep, such as difficulty staying awake during routine activities. The global PSQI scores ranges from 0 to 21, and is obtained by adding the subscores of the seven components, with high scores corresponding to poor sleep quality. Each subscale score is weighed equally on a scale from 0 to 3. A global score of > 5 is indicative of disturbed sleep. The PSQI demonstrates good internal consistency ($\alpha = 0.754$).

Neuroticism

Neuroticism, from the 44-item Big Five Inventory (BFI) [15], was used to assess neuroticism scores. Eight items in total are rated on a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree), with higher scores reflecting greater neuroticism. The measure demonstrated good internal consistency in the current sample ($\alpha = 0.702$).

Mindfulness

The Mindful Attention Awareness Scale (MAAS) was developed by Brown and Ryan to measure the level of awareness of and attention to present events and experiences [35]. This scale has displayed good psychometric properties in the Chinese population. The MAAS is a 15-item self-reported scale, with each item ranging in score from 1 (almost always) to 6 (almost never). Participants were instructed to rate how frequently they had experienced the feeling stated in each item. Higher scores indicate a higher level of mindfulness. In the current sample, the MAAS demonstrated good internal consistency ($\alpha = 0.867$).

Statistical analysis

Data were analyzed using the SPSS statistical package (SPSS 22.0, SPSS, Inc., Chicago, IL, USA) and Mplus version 7.4 statistical software (Muthén and Muthén, Los Angeles, CA, USA). Continuous variables were described using the mean and standard deviation (*SD*), and categorical variables using frequencies with percentages. Student's *t* test and one-way ANOVA were performed to examine the differences in sleep quality according to the categorical socio-demographic and disease-related characteristics. Pearson's product-moment correlation coefficient (*r*) was used to determine bivariate direction and size among variables.

Mplus 7.4 was used to perform structural equation modeling (SEM) to test the mediating effect of mindfulness on neuroticism and sleep quality [36]. The mediation model was established with neuroticism as the independent variable, sleep quality as the dependent variable, and mindfulness as the mediating variable in the present study. Maximum likelihood estimation was employed in the mediation model because data for all continuous variables were normally distributed. The latent variable models were used to overcome the bias effects of measurement errors in path analysis models. The observations on the seven PSQI components were loaded onto the latent variable PSQI. Generally, using parcels as indicators of constructs has higher reliability than summing the items in a scale to create a total scale score [37, 38]. So item parceling (combining items into small groups within scales) was conducted to control inflated measurement errors [39]. Three item parcels for mindfulness with a factorial balance approach of item-to-construct balance were created (MAAS1 includes items 1, 2, 5, 6, and 7; MAAS2 includes items 4, 8, 10, 13, and 14; MAAS3 includes items 3, 9, 11, 12, and 15) [23]. Neuroticism was the observable variable. The goodness of fit of the acceptable model was as follows: root mean square error of approximation (RMSEA) ≤ 0.08, comparative fit index (CFI) ≥ 0.90, Tucker-Lewis index (TLI) ≥ 0.90, and standardized root mean square residual (SRMR) ≤ 0.08 [40]. Researchers recommended the use of the bootstrapping as a potent and effective method for testing the significance of the indirect effect of mediation. The indirect effect is deemed to be significant at the 0.05 level if the bias corrected 95% confidence interval (CI) from 5000 bootstrap samples does not include zero [41].

Results

Sample characteristics and sleep quality

The participants' socio-demographic information and disease-related differences in sleep quality (global PSQI scores) are shown in Table 1. The participants' mean age was 50.30 ($SD = 14.76$, ranging from 18 to 78 years). The mean global PSQI score was 7.57 ($SD = 3.25$), and 135 participants (69.9%) reported sleep disturbance (global PSQI score, 9.15 ± 2.49). In addition, the PSQI scale has two specific items on breathing and cough/snoring loudly that related to asthma. As a result, these symptoms were analyzed in asthmatics, which showed that 77.2% and 79.8% of them reported difficulties in breathing and cough/snoring, respectively. Individuals who reported higher global PSQI scores had the following characteristics: female, older, longer medical history, more frequent attacks, and more complications (pneumothorax, pneumomediastinum, atelectasis, chronic obstructive pulmonary disease, and bronchiectasis). Seven subscales of the PSQI are shown in Table 2.

Correlations between neuroticism, mindfulness, and sleep quality

Pearson correlation analysis showed negative relationships between neuroticism and mindfulness ($r = -0.360$, $P < 0.001$) along with a positive relationship between neuroticism and global PSQI scores ($r = 0.225$, $P < 0.01$), and mindfulness scores negatively correlated with global PSQI scores ($r = -0.284$, $P < 0.001$). In addition, there was a significant positive correlation between age and global PSQI scores: the older the subject, the poorer the subject's sleep quality (Table 3).

Table 2 Seven components of PSQI among asthma patients

Components of PSQI		*N*	%
Subjective sleep quality (S1)	Very good	25	13.0
	Good	89	46.1
	Bad	76	39.4
	Very bad	3	1.6
Sleep latency (S2)	0	10	5.2
	1~2	77	39.9
	3~4	61	31.6
	5~6	45	23.3
Sleep duration (S3)	> 7 h	100	51.8
	6~7 h	86	44.6
	5~6 h	7	3.6
	< 5 h	0	0.0
Habitual sleep efficiency (S4)	> 85%	186	96.4
	76~85%	6	3.1
	66~75%	1	0.5
	< 66%	0	0.0
Sleep disturbances (S5)	0	8	4.1
	1~9	76	39.4
	10~18	97	50.3
	19~27	12	6.2
Use of sleeping medication (S6)	0	107	55.4
	< 1 times/week	37	19.2
	1~2 times/week	38	19.7
	≥ 3 times/week	11	5.7
Daytime dysfunction (S7)	0	16	8.3
	1~2	66	34.2
	3~4	82	42.5
	5~6	29	15.0

Mediating effect of mindfulness on neuroticism and sleep quality

The mediation model of mindfulness and the standardized coefficients for each variable are shown in Fig. 1. Sleep duration (S3) and habitual sleep efficiency (S4) were ruled out in the model because their factor loads in the latent variable of sleep quality were too low (< 0.30). The SEM indicated significant regression paths, with all the path coefficients

Table 3 Correlations between neuroticism, mindfulness, and PSQI scores

Variables	*M* ± SD	Age	Neuroticism	Mindfulness
Age	50.30 ± 14.76	–	–	–
Neuroticism	22.41 ± 4.78	0.126	–	–
Mindfulness	63.49 ± 9.35	− 0.118	− 0.360***	–
PSQI	7.57 ± 3.25	0.258***	0.225**	− 0.284***

$^{**}P < 0.01$; $^{***}P < 0.001$

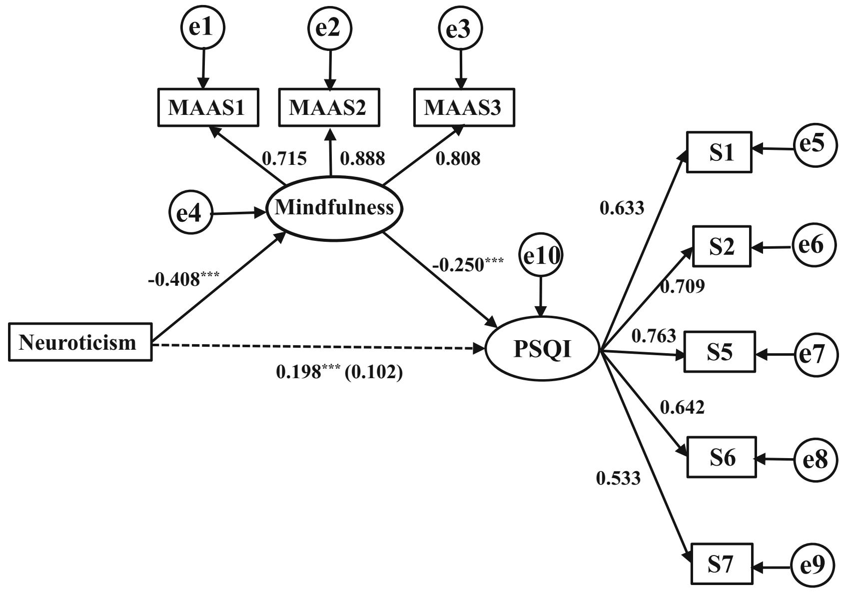

Fig. 1 The mediation model of mindfulness on neuroticism and sleep quality ($N = 193$). S1, subjective sleep quality; S2, sleep latency; S5, sleep disturbances; S6, use of sleeping medications; S7, daytime dysfunction. Dotted line, the standardized direct effect of neuroticism on the PSQI scores was not statistically significant ($\beta = 0.102$, $P = 0.218$). The fit indices for the modified model were acceptable: chi-square (χ^2) = 101.442, df = 60, RMSEA = 0.060, TLI = 0.915, CFI = 0.933, SRMR = 0.052

statistically significant at the level of $P < 0.05$. The fit indices for the model were acceptable: chi-square (χ^2) = 101.442, df = 60, RMSEA = 0.060, TLI = 0.915, CFI = 0.933, SRMR = 0.052.

Univariate analysis suggested that age, gender, medical history, attack times, and complications were significantly associated with sleep quality, so these variables were controlled prior to analyzing the mediation in adjusted model. Based on the adjusted model, neuroticism was significantly related to mindfulness; the standardized direct effect value of neuroticism on mindfulness was − 0.408 ($P < 0.001$), and the standardized direct effect value of mindfulness on the global PSQI scores was − 0.250 ($P = 0.006$). In addition, the standardized total and direct effect of neuroticism on the global PSQI scores were 0.198 ($P = 0.006$) and 0.102 ($P = 0.218$), respectively. The standardized indirect effect value of neuroticism on the global PSQI scores through mindfulness was 0.102 (− 0.408 × − 0.250). The bootstrapped 95% CI did not include zero (0.032, 0.208, $P = 0.021$) for the indirect effect of neuroticism on the global PSQI scores through mindfulness, identifying the significant indirect effect.

Discussion

Sleep disturbance was observed in the majority of asthmatic individuals in the study, especially in those who were female and older, and had longer medical history, more frequent attacks, and more complications, which is consistent with the findings of Sanz de Burgoa's study in adults with asthma [11]. In conclusion, sleep problems in individuals with asthma are worthy of concern.

As demonstrated by our data, neuroticism was negatively associated with sleep quality, which was in accordance with earlier findings in non-asthma samples [15, 42]. The results demonstrated a model for understanding the relationship between neuroticism and sleep quality in asthmatic individuals. Asthmatic individuals with high neuroticism may have advanced somatic and emotional arousal at bed time for fear of asthma attacks or nocturnal exacerbation of asthma, making it more difficult for them to fall asleep and leaving them vulnerable to difficulty sleeping [43]. Thus, greater concern should be paid to those asthma patients who are susceptible to sleep disturbance.

Encouragingly, our findings confirmed that mindfulness was positively related to sleep quality among asthma patients, which was congruent with previous findings of a longitudinal study [44]. One possible explanation for the positive association between mindfulness and sleep quality is that mindful individuals can perceive their immediate experience with a conscious, open, and accepting awareness and attentiveness, rather than focusing inward on their asthma and themselves [35], thereby decreasing their anxiety and increasing sleep quality. Additionally, researchers understand the connection between mindfulness and sleep quality from a neurobiological perspective. High mindfulness can significantly decrease hypothalamus-pituitary-adrenocortical system activity (HPASA) [45], and thereby maintain regular sleep-wake rhythms, which is conducive to good sleep [46, 47]. Taken together, the results of this study verify the relationship between mindfulness and sleep quality in asthmatics.

Most importantly, the present study suggested that mindfulness might play a mediating role between neuroticism and sleep quality in individuals with asthma. Concretely speaking, high neuroticism was associated with low levels of mindfulness, which in turn was associated with poor sleep quality, and vice versa. Highly neurotic patients with asthma tend to pay more attention to negative feelings and worry about relapse of asthma [14], which will disturb the processing of mindfulness [48] and lead to sleep problems eventually. The latent mediating mechanism of mindfulness on neuroticism and sleep quality implied that intervention and prevention programs on mindfulness may be beneficial in improving sleep quality in asthma patients.

Although this study has strengths as mentioned above, several limitations should be taken into consideration. First, the study used a cross-sectional design, so causality among variables could not be inferred. Although neuroticism could predict mindfulness in this study, mindfulness might shape personality traits or both are shaped by other factors [49]. Considering the dynamic interrelationships between neuroticism, mindfulness, and sleep quality, longitudinal designs should be employed. In addition, intervention studies such as mindfulness-based practice might be also required in the future. Second, the present study depended entirely on self-reported measures, which can produce common method variance (CMV). In the future, perhaps we can apply objective measures to assess sleep quality by recording brain waves during sleep, such as polysomnography (PSG). Third, we measured sleep patterns by PSQI only. Further studies should be performed to evaluate obstructive sleep apnea, insomnia, or other sleep disorders among asthmatics. Additionally, we did not assess the PSQI scores according to the classification of asthma severity, but it deserves to be explored in future studies. What's more, the sample size of the present study may be insufficient for SEM. Rigdon indicated that a sample size of at least 200 guarantees stability of model fit [50]. Although the fit indices for the mediator model could ultimately be acceptable, further investigation using a large sample is necessary. Additionally, the small correlation coefficients from our results may have been improved with a larger sample.

Conclusions

Sleep disturbance in asthma patients is very common and worthy of concern. Our results indicated that asthmatic individuals with high neuroticism experience more disturbed sleep, but also that mindfulness is a positive factor for better sleep. The underlying mediating mechanism of mindfulness on neuroticism and sleep quality provides new insight to improve sleep quality among highly neurotic asthma patients.

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Compliance with ethical standards

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

Ethical approval Questionnaires were distributed to participants who agreed to participate in the study after being informed of it. This study was approved by the Institutional Review Board of the authors' institutes and was performed in accordance with the ethical standards of the institution and the 1964 Declaration of Helsinki and its later amendments.

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