Psychology Research and Behavior Management

Dovepress
Taylor & Francis Group

Open Access Full Text Article

ORIGINAL RESEARCH

Innovative Analysis of the Interconnected Network Structure Between Anxiety and Sleep Quality Among College Students

Yang He[1–3], Tianqi Yang[2], Qingjun Guo[3], Shengjun Wu[2], Wei Liu[1], Tao Xu[3]

[1]School of Psychology, Shanghai Normal University, Shanghai, 200234, People's Republic of China; [2]Department of Military Medical Psychology, Air Force Military Medical University, Xi'an, 710032, People's Republic of China; [3]Department of Psychology, Second Sanatorium of Air Force Hangzhou Special Recreation Centre, Hangzhou, 310007, People's Republic of China

Correspondence: Wei Liu; Tao Xu, Email lwei0922@163.com; hangzhou310007@163.com

Background: A complex interplay exists between anxiety and sleep quality. However, there is a scarcity of network analysis studies examining this relationship, particularly among college students. Previous research has relied on sum scores from scales, which fails to capture the nuanced, symptom-level associations between anxiety and sleep quality. This limitation impedes a comprehensive understanding of their interactions. Thus, the objective of this study was to address this research gap by employing network analysis to explore symptom-level associations between anxiety and sleep quality within a college student population.

Methods: Network analysis was conducted to explore the association between anxiety and sleep quality among college students and identify bridge items of anxiety and sleep quality. Anxiety was assessed via the Self-Rating Anxiety Scale (SAS), and sleep quality was assessed via the Pittsburgh Sleep Quality Index (PSQI).

Results: The network structure revealed 47 significant associations between anxiety and sleep quality. "Subjective sleep quality", "daytime dysfunction", "panic", "dizziness", "fatigue" and "sleep disorder" had higher EI values in the network. "fatigue" and "daytime dysfunction" had the highest BEI values in their respective communities.

Conclusion: From a network analysis perspective, this study identified complex pathways of pathological correlations between anxiety and sleep quality among college students. It also identified "subjective sleep quality", "daytime dysfunction", "panic", and "dizziness", "fatigue" and 'sleep disturbance' may be potential targets for intervention in anxiety-sleep disorder comorbidity. In the future, psychologists and medical professionals may adopt appropriate interventions based on the centrality index and bridging centrality indicators identified in this study to effectively reduce the comorbidity of anxiety and sleep disorders in college students.

Keywords: network analysis, anxiety, sleep quality, college students, prevention

Background

Sleep disorders are a physiological phenomenon in which an individual's normal rhythmic alternation of sleep and wakefulness is disturbed, which mainly include insomnia, poor sleep quality and other symptoms.[1–3] According to statistics from the World Health Organization (WHO), 27% of the world's population experiences sleep problems, and sleep disorders have become a prominent problem that threatens the world population.[4] However, the situation in China is not optimistic, according to the statistics of China Sleep Data Report in March 2023, the average sleep duration in China is 6.5 hours, and the proportion of people suffering from various types of sleep disorders is as high as 38.2%, and about 510 million Chinese have sleep disorders, and insomnia has a serious impact on the quality of people's life and work.[5] In recent years, with the rapid development of society and the intensification of competition, college students face many challenges and pressures, and the problem of sleep disorders is becoming more and more prominent, and its incidence is as high as 26%.[6] It is well known that sleep, as an essential physiological activity, is closely related to the growth of college students, especially brain development.[7] Sleep disorders have been shown to lead to brain and body dysfunction, causing neurasthenia, endocrine disorders, and memory and resistance loss, as well as potentially inducing some psychological disorders (ie, anxiety disorders

Received: 18 November 2024
Accepted: 21 February 2025
Published: 13 March 2025

and depression), which can greatly affect the daily lives of college students.[8–10] Moreover, sleep problems in college students not only affect their learning efficiency but also may lead to suicidal thoughts and induce suicidal events.[11] Therefore, it is necessary to understand the factors affecting sleep disorders among college students in China and to prevent and intervene early to maintain their physical and mental health.

Currently, as an integral component of health and growth, many psychological factors related to sleep disorders, such as anxiety symptoms, have received extensive attention from researchers.[12–14] Anxiety refers to a series of unpleasant emotional and physical symptoms, such as panic, fear, and dread that people experience in risky situations due to the fear of a potential negative outcome.[15] Studies have shown that anxiety is positively correlated with sleep disorders and can directly and positively predict the quality of sleep in college students,[9] and college students who meet the criteria for anxiety score significantly higher than those who do not in terms of poor sleep quality.[16] In addition, researchers have reported that poor sleep quality is associated with generalized anxiety disorder.[17,18] Alfano et al[19] reported that 88% of 128 children and adolescents with anxiety disorders had varying degrees of sleep problems. In recent years, many studies have shown that the relationship between sleep quality and anxiety symptoms may be complex or bidirectional; for example, better sleep quality can effectively improve anxiety disorders in college students, whereas poorer sleep quality can lead to the development of anxiety disorders and exacerbate existing symptoms.[10,20–22]

However, previous research on anxiety and sleep quality in college students has tended to treat each as a whole, ie, examining their correlations on the basis of the total scores of the two scales, while truly ignored a fine-grained understanding of the symptomatic level of the relationship between the two. The Self-Rating Anxiety Scale (SAS) contains 20 items,[23] and the Pittsburgh Sleep Quality Index (PSQI) contains seven factors.[24] These symptoms may be a response to different specific risk factors and represent unique risk mechanisms; for example, Zhang et al[25] used network analysis and reported that the 19th entry in the SAS, "sleep disorder", had the strongest correlation with sleep quality in the network structure. In other words, it is necessary to explore patterns of associations between individual symptoms of anxiety and factors of sleep quality, as fine-grained studies can provide the best targets for effective interventions.

Network analysis provides a viable methodological basis for exploring the fine-grained relationships between different types of anxiety and different factors of sleep quality. Network analysis is an emerging method for the statistical analysis and visualization of data, which can deepen the understanding of psychological constructs or mental disorders from a network perspective and provide some reference for the selection of potential intervention targets.[26,27] In addition, network structures consist of nodes representing psychological variables and connecting lines representing statistical relationships between variables, and the centrality of each node in the network (ie, each item or factor of the questionnaire) can be calculated to assess the relative importance of the different interconnected nodes in the network.[28] Nodes that activate high centrality are more likely to transmit the effect to the entire network through connections between nodes,[29] which provides an important potential target for implementing relevant interventions. In particular, network analysis can effectively address the issue of spurious correlation that arises due to the large number of variables, compared to traditional statistical models, thereby ensuring the accuracy and reliability of the analysis results.[30]

In summary, the relationship between anxiety and sleep quality among college students has been extensively explored. Yet, most studies have relied on latent variable analyses, which possess inherent limitations in unveiling the intricate relationships among variables. Latent variable analyses typically concentrate on overall associations, rendering it challenging to capture the nuanced connections between specific symptoms and their dynamic interactions.[31] Conversely, network analyses have paved a new avenue for research in this domain, innovatively enabling a deep dive into both direct and indirect associations between variables, thereby uncovering potential bridging symptoms and intricate pathways of pathological correlations.[32] Network analysis not only transcends the constraints of traditional statistical methods in grasping the complex interrelationships among variables but also equips researchers with the capability to pinpoint the crucial targets for interventions by constructing intuitive network models.[28,33]

The significance of Chinese college students as a specific target population for this research cannot be overlooked. They are situated within unique academic pressures, social expectations, and cultural contexts, which collectively influence their psychological state and may exert a profound impact on anxiety and sleep quality.[34] Previous studies have found that one-third of Chinese university students suffer from sleep quality problems.[35] In addition, mental health problems (eg, anxiety) are prevalent in the university population.[36]

However, despite the abundance of studies on anxiety and sleep quality among college students, there is a relative scarcity of web-based analyses focusing specifically on this cohort of Chinese college students. This situation not only impedes our comprehensive understanding of the interplay between their anxiety and sleep quality but also obstructs the development and implementation of effective prevention and intervention strategies.

Therefore, this study used network analysis to investigate the fine-grained relationship between anxiety and sleep quality in college students. We developed a network model to explore the correlation pathways between the symptoms of anxiety and sleep quality and assessed centrality indices and bridge centrality indicators to provide theoretical support for the prevention and intervention of anxiety and sleep quality in college students.

Methods

Participants

Between August and October 2023, 2600 college students were recruited from two institutions of higher learning in Anhui Province, China, via the www.wjx.cn platform to participate in an online survey for this study. We employed two internationally recognized psychological assessment tools: the Self-Assessment Anxiety Scale (SAS) and the Pittsburgh Sleep Quality Index (PSQI). These tools were used to anonymously assess the anxiety levels and sleep quality of Chinese university students. It is worth noting that the reliability and validity of both the SAS and PSQI have been extensively validated in the Chinese college student population, meeting high international standards.[37–39]

To ensure data quality, we implemented a rigorous screening process for our data. Drawing upon statistical principles, specifically the rule of thumb for excluding outliers within ±2 standard deviations, we established a response time threshold. Recognizing that some participants may take longer to respond due to careful consideration, we only deemed questionnaires with unusually short response times (≤150 seconds) as invalid. Consequently, we excluded 50 questionnaires, resulting in a data validity rate of 98.07%. The study was approved by the Medical Ethics Committee of the Air Force Hangzhou Special Recreation Centre (TLZX20240725-01) and was conducted in strict accordance with the Declaration of Helsinki.

Measurements

Self-Rating Anxiety Scale (SAS)

The SAS, developed by Zung in 1971, is an internationally recognized self-assessment tool for anxiety symptoms.[40] In this study, we used the Chinese version of the SAS, which was revised by Tao and Gao.[41] It consists of 20 questions, each of which is rated on a scale from 1 to 4 according to the subjective feelings experienced during the previous week: 1-no or a little of the time; 2-some of the time; 3-a good part of the time; and 4-most or all of the time. The cutoff value in our study was 50, and the higher the score was, the more pronounced the anxiety symptoms. The questionnaire had excellent internal consistency in this study (Cronbach's alpha = 0.931).

Pittsburgh Sleep Quality Index (PSQI)

The PSQI, developed by Buysse et al[42] in 1989, is used to measure the quality of a person's sleep and the degree of sleep disorders during the past month. In this study, we used the Chinese version of the PSQI, which was revised by Liu and Tang.[38] A total of 18 items are included in the scale, which are categorized into seven dimensions: (1) subjective sleep quality; (2) sleep latency; (3) sleep duration; (4) habitual sleep efficiency; (5) sleep disorders; (6) use of hypnotic medications; and (7) daytime dysfunction. Each dimension is rated on a scale from 0–3, and these composite scores are summed to produce an overall PSQI total score representing overall sleep status. The total score ranges from 0 to 21, with higher scores indicating poorer sleep status. The questionnaire had excellent internal consistency in this study (Cronbach's α= 0.83).

Data Analysis

Descriptive Statistics

All descriptive data were analyzed via SPSS 25.0 software, and all the statistical analyses were performed via the R statistical programming language and R 4.1.1 software.

Network Analysis

The R package qgraph was used to construct and visualize a sleep quality–anxiety network.[43] The network was fitted by a Gaussian graphical model (GGM).[30] During the network construction process, a combination of least absolute shrinkage and selection operator (LASSO) regularization and the extended Bayesian information criterion (EBIC) was used to attenuate trivial edges to zero, resulting in a stable and clear network.[30,44] Additionally, we set the EBIC hyperparameter to 0.5 to determine the construction of an optimal network model.[45] In this network model, the nodes represent the variables (ie, the seven factors of the PSQI and the 20 items on the SAS), which are divided into sleep quality and anxiety communities; each edge represents the partial correlation between two nodes.[30] The blue line represents a positive correlation between anxiety symptoms and sleep quality, whereas the red line represents a negative correlation between anxiety symptoms and sleep quality. The thickness of the line and the saturation of the color represent the magnitude of the correlation; the thicker the line is, the greater the correlation between the two nodes, and vice versa. In addition, we tested the accuracy of edge weights and differences in node pairs via the R package bootnet.[46] Additionally, 95% confidence intervals (CIs) were estimated via a nonparametric bootstrap method (1000 bootstrap samples), mainly to test the accuracy between edge weights. The relatively narrow CIs indicate that the accuracy of the edge weight estimates is acceptable.[47] We also tested the edge weight differences between node pairs by bootstrapping ($\alpha = 0.05$, 1000 bootstrap samples).

In addition, we use the networktools[48] and bootnet[46] software packages to compute and evaluate the expected influence (EI) and bridge expected influence (BEI) of each node. The EI of a node is calculated from the sum of the edge weights of all the edges connected to that node to measure its importance in the network structure.[49] A higher EI signifies a node of greater importance and influence within the network.[29] Conversely, the BEI of a node is the sum of the edge weights between the node and all the nodes of other communities, which mainly reflects the influence of the node on other communities.[48] A higher BEI value indicates an increased likelihood of contagion spreading across communities.[50] Additionally, we used the case-dropping bootstrapping method to test the stability of the EI and BEI[46] (1000 bootstrap samples). We then quantified the stability of the EI and BEI via the correlation stability (CS) coefficient. In general, a CS coefficient greater than 0.25 indicates acceptable stability, whereas a CS coefficient greater than 0.5 indicates desirable stability.[51] Finally, we tested the difference between the EI and BEI of different nodes via the parametric bootstrap method (1000 bootstrap samples, $\alpha = 0.05$).

Results

Demographic Characteristics and Descriptive Statistics

In our study, the final population included 2550 college students with a mean age of 22.93 ± 1.33 years. Among these students, 1510 (59.21%) were female. Table 1 shows the means, standard deviation, and EI and BEI values of the scores for each item of the PSQI and SAS.

Network Structure

The network model is shown in Figure 1A. There were 47 nonzero edges (edge weights ranging from −0.03 to 0.24) across the anxiety symptoms and sleep quality communities in the network. In the edges across communities, S1“subjective sleep quality” was positively correlated with 7 nodes of the anxiety community, and the strongest positive edge was that of A19 “sleep disorder” (edge weight = 0.08). S2 “sleep latency” was positively correlated with 9 nodes of the anxiety community, and the strongest edge was that of A19 “sleep disorder” (edge weight = 0.12). S3 “sleep duration” was positively correlated with 5 nodes of the anxiety community, and the strongest correlation was observed for A19 “sleep disorder” (edge weight = 0.04). S4 “habitual sleep efficiency” was positively correlated with 2 nodes of the anxiety community, and the strongest correlation was observed for A10 “tachycardia” (edge weight = 0.02). S5 “sleep disturbance” was positively correlated with 9 nodes of the anxiety community, and the strongest correlation was observed for A16 “frequent urination” (edge weight = 0.05). S6 “hypnotic drugs” was positively correlated with 7 nodes of the anxiety community, and the strongest correlation was observed for A11“dizzy” (edge weight = 0.08). S7 “daytime dysfunction” was positively correlated with 8 nodes of the anxiety community, and the strongest correlation was

Table 1 The Means, Standard Deviations, and EI and BEI Values of the Anxiety-Sleep Quality Variables

Variables	Abbreviations/Dimensions	M	SD	EI	BEI
Sleep quality					
S1: Subjective sleep quality	Subjective sleep quality	0.65	0.71	1.15	0.29
S2: Sleep latency	Sleep latency	0.76	0.76	0.78	0.24
S3: Sleep duration	Sleep duration	0.88	0.82	0.92	0.10
S4: Habitual sleep efficiency	Habitual sleep efficiency	0.61	0.66	0.49	0.03
S5: Sleep disturbance	Sleep disturbance	0.76	0.60	0.78	0.21
S6: Hypnotic drugs	Hypnotic drugs	0.01	0.19	0.33	0.30
S7: Daytime dysfunction	Daytime dysfunction	0.66	0.69	1.15	0.46
Anxiety					
A1: I feel more nervous and anxious than usual	Anxiety	1.16	0.42	0.99	0.16
A2: I am scared for no reason	Fear	1.05	0.26	0.87	0.06
A3: I tend to get upset or feel panicky	Panic	1.11	0.37	1.10	0.08
A4: I think I might be going insane	Sense of insanity	1.05	0.27	0.91	0.08
A5: I think everything is bad and misfortune will happen	Unfortunate premonition	1.15	0.42	0.66	0.00
A6: My hands and feet are shaking and trembling	Shaking of the hands and feet	1.05	0.25	0.84	0.00
A7: I suffer from headaches, neck pain and back pain	Somatic pain	1.15	0.42	0.95	0.17
A8: I feel easily weakened and tired	Fatigue	1.21	0.49	1.05	0.32
A9: I cannot sit calmly and easily	Meditation is not possible	2.51	1.33	0.95	0.02
A10: I think my heart's beating fast	Tachycardia	1.12	0.39	0.86	0.08
A11: I am suffering from a bout of dizziness	Dizzy	1.06	0.27	1.09	0.09
A12: I have fainting episodes or feel like I am going to faint	Fainting spells	1.06	0.28	0.82	0.00
A13: I am having a hard time breathing in and out	Breathing difficulty	2.39	1.44	0.61	0.03
A14: I have numbness and tingling in my hands and feet	Tingling in the hands and feet	1.07	0.30	0.94	0.00
A15: I suffer from stomach pains and indigestion	Stomach pains or indigestion	1.11	0.37	0.66	0.10
A16: I have to urinate often	Frequent urination	1.34	0.61	0.33	0.08
A17: My hands are often sweaty	Hyperhidrosis	2.38	1.32	0.83	0.03
A18: I am flushed and hot	Facial flushing	1.16	0.45	0.69	0.01
A19: I do not fall asleep easily and get a poor night's sleep	Sleep disorder	2.21	1.26	1.05	0.26
A20: I am having nightmares	Nightmares	1.13	0.36	0.58	0.17

Notes: Adapted from Psychosomatics. Volume 12(6). Zung WWK. A rating instrument for anxiety disorders. 371–379, Copyright 1972, with permission from Elsevier.[40]
Abbreviations: M, mean; SD, standard deviation; EI, expected influence; BEI, bridge expected influence.

observed for A8 "fatigue", (edge weight = 0.24). See Supplementary Table S1 for more detailed information on the correlations among the nodes in the network.

The bootstrapped 95% confidence interval for estimated edge weights is narrow, indicating that the edges were estimated accurately and reliably (see Supplementary Figure S1). The bootstrapped difference test for edge weights is shown in Supplementary Figure S2, revealing that the weights of the 7 strongest edges were significantly higher than 88%–100% of the weights of other edges.

Network Central Symptoms and Bridge Symptoms

Figure 1B shows the EI values for each node in the sleep quality–anxiety network. The results revealed that S1"subjective sleep quality", S7 "daytime dysfunction", A3 "panic", A11"dizzy", A8 "fatigue", A19 "sleep disorder" had the highest positive EI values (EIs =1.15, 1.15, 1.1, 1.09, 1.05 and 1.05, respectively). The BEI indices for each node are shown in Figure 1C, indicating that in the sleep quality and anxiety communities, S7 "daytime dysfunction" and A8 "fatigue" presented the highest BEI values in their respective communities (BEI= 0.46 and 0.32). Thus, A8 "fatigue" and S7 "daytime dysfunction" were considered bridge symptoms in the anxiety-sleep quality network.

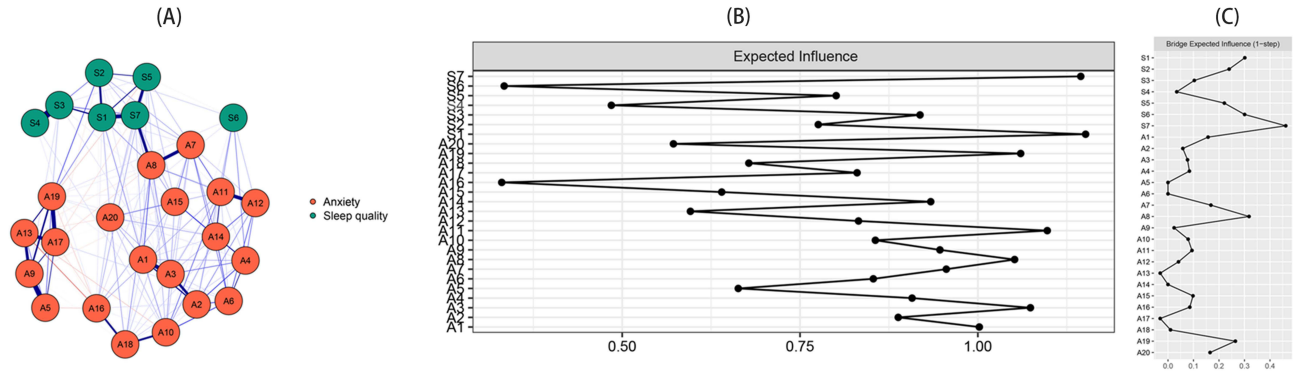

Figure 1 The anxiety and sleep quality network structure among Chinese college students and the expected influence and bridge expected influence of the nodes in the network. **Notes**: (**A**) The network model of anxiety and sleep quality. The nodes represent items of anxiety and sleep quality, the blue lines represent positive correlations between anxiety symptoms and sleep quality, the red lines represent negative correlations between anxiety symptoms and sleep quality, and the thickness of the line and the saturation of the color represent the magnitude of the correlation. In cross-community edges, the strongest correlation of S1 was with A19, the strongest correlation of S2 was with A19, the strongest correlation of S3 was with A19, the strongest correlation of S4 was with A10, the strongest correlation of S5 was with A16, the strongest correlation of S6 was with A4, the strongest correlation of S7 was with A8. (**B**) The expected influence indices in the network of anxiety and sleep quality (raw score). S1"subjective sleep quality", S7 "daytime dysfunction", A3 "panic", A11 "dizzy", A8 "fatigue", A19 "sleep disorder" had the highest positive EI values (EIs =1.15, 1.15, 1.1, 1.09, 1.05 and 1.05, respectively). (**C**) The bridge expected influence indices in the network of anxiety and sleep quality (raw score). A8 had the highest bridge expected influence value (0.32) in the anxiety community, while S7 had the highest bridge expected influence value (0.46) in the sleep quality community. S1 = subjective sleep quality; S2 = sleep latency; S3 = sleep duration; S4 = habitual sleep efficiency; S5 = sleep disturbance; S6 = hypnotic drugs; S7 = daytime dysfunction; A1 = anxiety; A2 = fear; A3 = panic; A4 = intelligence; A5 = misfortune premonition; A6 = tremor; A7 = somatic pain; A8 = fatigue; A9 = restlessness; A10 = tachycardia; A11 = dizziness; A12 = fainting spells; A13 = breathing difficulty; A14 = tingling; A15 = stomach pains or indigestion; A16 = frequent urination; A17 = hyperhidrosis; A18 = facial flushing; A19 = sleep disorder; A20 = nightmares.

In addition, in the current network, the EI indices of S1"subjective sleep quality", S7 "daytime dysfunction", A3 "panic", A11 "dizzy" and A19 "sleep disorder" were significantly different from the EI indices of most other nodes ($P < 0.05$; see Supplementary Figure S3). Furthermore, the BEI indices of A8 "fatigue", A19 "sleep disorder", and S7 "daytime dysfunction" were significantly different from those of most other nodes ($P < 0.05$; see Supplementary Figure S4). From the results of the stability tests of the EI and BEI values, we found that the mean correlation of the original sample slowly decreased as the sample sampling proportion decreased (Supplementary Figures S5 and S6). In this study, the CS coefficients were 0.75 for the EI value and 0.75 for the BEI value, indicating that the estimates of both the EI and the BEI values were sufficiently stable

Discussion

Sleep problems are an emerging global epidemic with potential negative effects on people's physical health,[52] work and study efficiency.[53] In this study, we utilized network analysis to construct a network structure between anxiety symptoms and sleep quality among Chinese college students and calculated the EI and BEI values of each node. To the best of our knowledge, few previous studies have used network analysis to investigate the relationship between these two structures. Therefore, the results of this study help us gain a deeper understanding of the relationship between sleep quality and anxiety symptoms among college students and identify potential targets for intervention, providing suggestions for future clinical prevention and intervention.

In the sleep quality–anxiety network, we found that S1"subjective sleep quality", S2 "sleep latency", and S3 "sleep duration" were most strongly and positively associated with A19 "sleep disorder". This result is consistent with previous research suggesting that sleep disturbance is one of the most common and problematic symptoms of anxiety disorders.[54–57] Sleep disorders are manifestations of abnormal sleep quality, abnormal behavior during sleep, and disturbances in the normal rhythmic alternation of sleep and wakefulness.[58] Studies have shown that patients with anxiety disorders often have sleep problems, which are characterized mainly by insomnia, poor sleep quality, difficulty falling asleep, and difficulty maintaining sleep with easy awakening.[59] For the college population, chronic anxiety may create a vicious cycle where sleep problems and anxiety symptoms exacerbate one another.[60] Specifically, anxiety can lead to difficulties in falling asleep, poor sleep quality, and challenges in maintaining sleep, while decreased sleep quality may further intensify anxiety

symptoms.[61] Therefore, interventions aimed at addressing sleep disorders in this group have the potential to break this vicious cycle and significantly improve their mental health.[62]

In the sleep quality–anxiety network, we found that S4 "habitual Sleep Efficiency" was most strongly and positively associated with A10 "palpitations". Palpitations are the sensation of a rapid or irregular heartbeat. Studies have shown that people with anxiety disorders are more likely to experience episodes of palpitations than people without anxiety disorders,[63] and palpitations are considered to be the only independent predictor of anxiety.[64] Sleep efficiency, on the other hand, is defined as the ratio of total sleep time at night to the total time spent lying in bed.[65] A recent study has also shown that anxiety is positively correlated with sleep efficiency,[66] which is consistent with the results of the present study. This may be attributed to the widespread anxiety among college students, stemming from academic and employment pressures, which leads to difficulties in initiating and maintaining sleep, and consequently, results in poor sleep efficiency. Extending the theoretical implications of this finding, our results emphasize the reciprocal relationship between sleep efficiency and anxiety, suggesting that interventions designed to improve sleep efficiency could potentially alleviate anxiety symptoms among this population.

In addition, the strongest positive correlation was found between S5 "sleep disorder", and A16 "urinary frequency", which is similar to the results of previous studies.[10] The relationship between sleep disorders and anxiety symptoms is bidirectional; for example, better sleep quality can effectively improve anxiety disorders in college students, whereas poorer sleep quality can lead to the emergence of anxiety disorders.[20–22] Furthermore, another study has shown that frequent urination is a manifestation of anxiety symptoms and may also impact sleep quality.[67] Therefore, when implementing anxiety interventions for college students, it is crucial to pay attention to issues such as sleep disorders and urinary frequency in order to enhance their overall mental well-being.

In addition, we found that S6 "hypnotic drugs" being most strongly correlated with A4 "Sense of insanity", which had the strongest association. This result further confirms that the use of hypnotic drugs may have side effects on college students, including Sense of insanity.[68] College students usually have poor sleep quality; specifically, they develop sleep disorders because the pressure of studying and the amount of homework assigned force them to frequently stay up late, and they often use hypnotic medications to help them sleep better.[69] While hypnotic drugs are a popular treatment option for many patients and clinicians, long-term use can lead to a variety of adverse effects.[70] For example, amine antagonist receptors may help improve individuals' sleep quality,[71] but the long-term administration of hypnotic drugs can trigger anticholinergic effects,[72] including adverse effects such as fever, blurred vision, tachycardia, dystonia, and confusion.[73] Therefore, hypnotic drugs should be used with caution, and alternative non-pharmacological treatments, such as cognitive-behavioral therapy, should be considered in interventions targeting sleep disorders and anxiety symptoms.

Notably, in our study, S7 "daytime dysfunction" exhibited the strongest positive correlation with A8 "fatigue", and the S7-A8 symptom pair emerged as the key bridging factor, further deepening our understanding of the complex relationship between sleep quality and anxiety networks. In today's fast-paced social environment, sleep problems and daytime dysfunction are becoming increasingly prevalent, particularly among college students.[74–76] Our finding is also consistent with previous research has shown that as daily stress levels increase, college students experience a significant decline in both the quantity and quality of their sleep, which directly leads to heightened fatigue and daytime dysfunction.[77–79] This finding underscores the importance of early identification and resolution of sleep issues to mitigate their potential negative impact on academic performance and overall well-being.[80] Furthermore, it emphasizes the urgent need to incorporate sleep health education and implement effective interventions within the school setting.[81] Thus, fostering a healthier sleep culture among college students is crucial for alleviating their sleep problems and enhancing their academic performance and overall well-being.

In addition, the EI value of a node is used to measure its importance in the network structure. A larger EI value of a node indicates a higher degree of centrality of that node.[29] The results of this study revealed that S1"subjective sleep quality", S7 "daytime dysfunction", A3 "panic", A11 "dizziness", A8 "fatigue", and A19 "sleep disturbance" were the core symptoms in the network. These findings suggest that these six nodes are important central nodes and that interventions targeting these nodes may provide the greatest generalized benefit to other nodes in the network.[82] In particular, it is more beneficial for college students who have both anxiety and sleep quality symptoms. A previous study revealed that "panic", "dizziness", and "lethargy", were central to the anxiety symptom–sleep quality network.[25] This

finding is partially consistent with our results. However, our findings are inconsistent with those of a recent study that reported that "irritability", "uncontrollable worry", "excessive worry", "fatigue", and "sleep deprivation" were central nodes of the anxiety–depression–insomnia symptom network.[83] This inconsistency likely stems from differences in the scales used and the variables included in the network. Since our study was preliminary and largely exploratory in nature, further studies are needed to validate our findings in the future.

Furthermore, the BEI of a node is defined as the sum of the edges connecting that node to all the nodes in the other symptom clusters, and nodes with higher BEI values may be perceived as having a higher risk of transmission from that symptom cluster to other symptom clusters.[50] Therefore, when a disorder is present, intervening in potential bridge-connecting symptoms can be effective in preventing the progression of the disorder and the development of complications. In the present study, we found that S7 "daytime dysfunction", and A8 "fatigue", had high positive BEI values in their respective associations. From a network perspective, this implies that interventions for "daytime dysfunction" and "fatigue" have a greater impact on comorbid anxiety and sleep disorders than other nodes in the anxiety symptom–sleep quality community do, making them potentially optimal targets for intervention. Fatigue is characterized by prolonged periods of tiredness, decreased energy, or weakness,[84] whereas daytime dysfunction refers to excessive daytime sleepiness, lethargy, and a lack of energy for work.[85] Previous studies have confirmed the relationship between fatigue and sleep disorders.[84,86] For example, Kim et al[87] reported that individuals with severe fatigue tended to report more severe insomnia symptoms than did those without fatigue and that interventions targeting fatigue symptoms were more effective in alleviating comorbid symptoms such as anxiety and insomnia symptoms in college students.[84] In contrast, insomnia, sleep deprivation, and poor sleep quality are typical symptoms of sleep disorders[88] and are closely associated with depression and anxiety.[89] College students with poor sleep quality exhibit high levels of fatigue, drowsiness, and difficulty concentrating during the day,[74] which may affect their ability to engage in normal social interactions. Therefore, appropriate management of sleep-related problems, especially daytime dysfunction, in college students is needed to improve the efficiency of interventions for sleep disorders and to save medical resources. For example, psychological pressure can be reduced through positive thinking therapy, physical exercise, and psychological counseling to improve sleep quality.

Finally, several limitations of this study are worth noting. First, this was a cross-sectional study that was unable to determine a causal relationship between anxiety symptoms and sleep quality. Therefore, in the future, we need to design longitudinal cohort studies that can elucidate causal relationships. For example, by tracking changes in anxiety and sleep quality of the same group of college students at different points in time, we can more accurately assess the dynamics between these symptoms, thereby revealing potential causal relationships between them. Second, the convenience sampling method employed in this study was primarily confined to the college student population in Anhui Province, potentially limiting the generalizability of the results. To verify the applicability of these findings to the nationwide college student population, we recommend the adoption of a larger, more representative sampling method in future studies. This could be accomplished through stratified random sampling across the country, ensuring that the sample accurately reflects the diversity of the college student population in terms of geographic regions, school types, and grade levels. By implementing such a research design, we can enhance the generalizability and reliability of our findings. Third, the current study primarily relied on self-assessment questionnaires to assess anxiety and sleep quality, potentially introducing recall bias or response bias. To address this limitation, we propose that future research endeavors develop more comprehensive assessment tools. These tools could integrate clinical diagnosis, objective measures (such as polysomnography, heart rate variability analysis, among others), and self-assessment questionnaires, thereby enhancing the accuracy and objectivity of the assessments.[90,91] By amalgamating multiple assessment methodologies, we can attain a more holistic understanding of the anxiety and sleep quality status among college students and furnish a scientific foundation for the development of effective interventions.

Conclusions

This study was the first to examine the relationship between sleep quality and anxiety symptoms in college students through network analysis, with the aim of identifying complex pathways of pathological correlation between anxiety and sleep quality among this population. The analysis identified "subjective sleep quality" (S1), "daytime dysfunction" (S7),

"panic" (A3), "dizziness" (A11), "fatigue" (A8), and "sleep disorder" (A19) as predominant central nodes. Notably, "daytime dysfunction" (S7) and "fatigue" (A8) emerged as critical bridge nodes. These results may offer insights for future research seeking to develop a theoretical understanding and provide implications for interventions tailored to meet the mental health needs of Chinese college students. In the future, psychologists and clinicians can adopt appropriate interventions based on the centrality indices and bridging indicators identified in this study to effectively reduce the comorbidity of anxiety and sleep disorders among college students.

Abbreviations

SAS, Self-rating anxiety scale; PSQI, The Pittsburgh sleep quality index scale; Anxiety, I feel more nervous and anxious than usual; Fear, I'm scared for no reason; Panic, I tend to get upset or feel panicky; Sense of insanity, I think I might be going insane; Unfortunate premonition, I think everything is bad and misfortune will happen.

Data Sharing Statement

The raw data supporting the conclusions of this article will be made available by the authors without undue reservation. Please contact the corresponding author.

Ethics Approval and Consent to Participate

The study was approved by the Medical Ethics Committee of the Air Force Hangzhou Special Recreation Centre (Approval Number: TLZX20240725-01). All participants voluntarily signed an informed consent form and participated anonymously. The study adhered to the principles outlined in the Declaration of Helsinki.

Declarations

We thank the participants for their thoughtful responses.

Author Contributions

All authors made substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; agreed to submit to the current journal; gave final approval of the version to be published; and agree to be accountable for all aspects of the work.

Disclosure

The authors declare no competing interests in this work.

References

1. Hu T, Wang Y, Lin L, Tang W. The mediating role of daytime sleepiness between problematic smartphone use and post-traumatic symptoms in COVID-19 home-refined adolescents. *Child Youth Serv Rev*. 2021;126:106012. doi:10.1016/j.childyouth.2021.106012
2. McLeish AC, Hartson KR, Walker KL, Hart JL. Associations between sleep disturbance, physical activity, and anxiety sensitivity among college students during the COVID-19 pandemic. *Psychol Health Med*. 2023;28(9):2512–2525. doi:10.1080/13548506.2023.2179082
3. Nicholson K, Rodrigues R, Anderson KK, Wilk P, Guaiana G, Stranges S. Sleep behaviours and multimorbidity occurrence in middle-aged and older adults: findings from the Canadian Longitudinal Study on Aging (CLSA). *Sleep Med*. 2020;75:156–162. doi:10.1016/j.sleep.2020.07.002
4. Vancampfort D, Van Damme T, Stubbs B, et al. Sedentary behavior and anxiety-induced sleep disturbance among 181,093 adolescents from 67 countries: a global perspective. *Sleep Med*. 2019;58:19–26. doi:10.1016/j.sleep.2019.01.048
5. C WY, Zhang Y, J QW, et al. Research progress on the relationship between novel coronavirus infection and sleep disorder. *International Journal of Psychiatry and Neurology*. 2024;13(01):1–7. doi:10.12677/ijpn.2024.131001
6. Zhou Y, Wang L, Fang X, et al. Prevalence of sleep disorders in the Chinese college students:A meta-analysis. *Occup and Health*. 2023;2705–2709.
7. Galván A. The need for sleep in the adolescent brain. *Trends Cognit Sci*. 2020;24(1):79–89. doi:10.1016/j.tics.2019.11.002
8. Yang H, Luan L, Xu J, Xu X, Tang X, Zhang X. Prevalence and correlates of sleep disturbance among adolescents in the eastern seaboard of China. *BMC Public Health*. 2024;24:1003.
9. Zhang C, Zhao L, Dong T, Zhao J, Gao C, Zhao F. A prospective study of sleep status, anxiety, and depression levels of college students at a university in Shandong Province, China. *Front Psychol*. 2024;15:1361632.
10. Zhang YT, Huang T, Zhou F, et al. Correlation between anxiety, depression, and sleep quality in college students. *Biomed Environ Sci*. 2022;35:648–651. doi:10.3967/bes2022.084
11. Wang D, Ross B, Zhou X, et al. Sleep disturbance predicts suicidal ideation during COVID-19 pandemic: a two-wave longitudinal survey. *J Psychiatr Res*. 2021;143:350–356. doi:10.1016/j.jpsychires.2021.09.038

12. Bøe T, Serlachius AS, Sivertsen B, Petrie KJ, Hysing M. Cumulative effects of negative life events and family stress on children's mental health: the Bergen child study. *Soc Psychiatry Psychiatr Epidemiol*. 2017;53(1):1–9. doi:10.1007/s00127-017-1451-4
13. Urfer-Maurer N, Weidmann R, Brand S, et al. The association of mothers' and fathers' insomnia symptoms with school-aged children's sleep assessed by parent report and in-home sleep-electroencephalography. *Sleep Med*. 2017;38:64–70.
14. Sivertsen B, Bøe T, Skogen JC, Petrie KJ, Hysing M. Moving into poverty during childhood is associated with later sleep problems. *Sleep Med*. 2017;37:54–59. doi:10.1016/j.sleep.2017.06.005
15. Pezzo MV, Beckstead JW. A multilevel analysis of rumor transmission: effects of anxiety and belief in two field experiments. *Basic Appl Soc Psychol*. 2006;28(1):91–100. doi:10.1207/s15324834basp2801_8
16. Ji C, Yang J, Lin L, Chen S. Anxiety and sleep quality amelioration in college students: a comparative study between team sports and individual sports. *Behav Sci*. 2022;12(5):149. doi:10.3390/bs12050149
17. Hertenstein E, Feige B, Gmeiner T, et al. Insomnia as a predictor of mental disorders: a systematic review and meta-analysis. *Sleep Med Rev*. 2019;43:96–105. doi:10.1016/j.smrv.2018.10.006
18. Baglioni C, Nanovska S, Regen W, et al. Sleep and mental disorders: a meta-analysis of polysomnographic research. *Psychol Null*. 2016;142:969–990.
19. Alfano CA, Ginsburg GS, Kingery JN. Sleep-related problems among children and adolescents with anxiety disorders. *J Am Acad Child Adolesc Psychiatry*. 2007;46:224–232.
20. Xiong W, Liu H, Gong P, et al. Relationships of coping styles and sleep quality with anxiety symptoms among Chinese adolescents: a cross-sectional study. *J Affect Disord*. 2019;257:108–115. doi:10.1016/j.jad.2019.07.032
21. Cahuas A, He Z, Zhang Z, Chen W. Relationship of physical activity and sleep with depression in college students. *J Am Coll Health*. 2020;68(5):557–564. doi:10.1080/07448481.2019.1583653
22. Cai H, Guo J, Zhou J, et al. Psychological resilience mediates the association between sleep quality and anxiety symptoms: a repeated measures study in college students. *PLoS One*. 2023;18(10):e0292887. doi:10.1371/journal.pone.0292887
23. Yue T, Li Q, Wang R, et al. Comparison of hospital anxiety and depression scale (hads) and zung self-rating anxiety/depression scale (SAS/SDS) in evaluating anxiety and depression in patients with psoriatic arthritis. *Dermatology*. 2020;236(2):170–178. doi:10.1159/000498848
24. He C, He Y, Yang T, et al. Relationship of sleep-quality and social-anxiety in patients with breast cancer: a network analysis. *BMC Psychiatry*. 2023;23(1):887. doi:10.1186/s12888-023-05262-1
25. Zhang Y, Wu L, J LY, et al. Network analysis of sleep quality and anxiety of first-line medical staff in epidemic prevention. *Chin Med Ethics*. 2023;36:167–173.
26. Stochl J, Soneson E, Wagner AP, Khandaker GM, Goodyer I, Jones PB. Identifying key targets for interventions to improve psychological wellbeing: replicable results from four UK cohorts. *Psychol Med*. 2019;49(14):2389–2396. doi:10.1017/S0033291718003288
27. Galderisi S, Rucci P, Kirkpatrick B, et al. Interplay among psychopathologic variables, personal resources, context-related factors, and real-life functioning in individuals with schizophrenia: a network analysis. *JAMA Psychiatry*. 2018;75(4):396–404. doi:10.1001/jamapsychiatry.2017.4607
28. Contreras A, Nieto I, Valiente C, Espinosa R, Vazquez C. The study of psychopathology from the network analysis perspective: a systematic review. *Psychother Psychosom*. 2019;88(2):71–83. doi:10.1159/000497425
29. Hofmann SG, Curtiss J, McNally RJ. A complex network perspective on clinical science. *Perspect Psychol Sci*. 2016;11:597–605.
30. Epskamp S, Fried EI. A tutorial on regularized partial correlation networks. *Psychol Methods*. 2018;23(4):617–634. doi:10.1037/met0000167
31. Eiko IF, Cramer AOJ. Moving forward: challenges and directions for psychopathological network theory and methodology. *Perspectives Psychol Sci*. 2017;12(6):999–1020. doi:10.1177/1745691617705892
32. Borsboom D. A network theory of mental disorders. *World Psychiatry*. 2017;16(1):5–13. doi:10.1002/wps.20375
33. Stefan GH, Curtiss J, Richard JM. A complex network perspective on clinical science. *Perspectives Psychol Sci*. 2016;11(5):597–605. doi:10.1177/1745691616639283
34. Wang Y, Guang Z, Zhang J, et al. Effect of sleep quality on anxiety and depression symptoms among college students in China's Xizang Region: the mediating effect of cognitive emotion regulation. *Behav Sci*. 2023;13(10):861. doi:10.3390/bs13100861
35. Li Y, W BAI, B ZHU, et al. Prevalence and correlates of poor sleep quality among college students: a cross-sectional survey. *Health Qual Life Outcomes*. 2020;18(1):210. [pmid:32611434]. doi:10.1186/s12955-020-01465-2
36. Li M, Liu L, Yang Y, Wang Y, Yang X, Wu H. Psychological impact of health risk communication and social media on college students during the COVID-19 pandemic: cross-sectional study. *J Med Internet Res*. 2020;22(11):e20656. doi:10.2196/20656
37. Liu XC, Sun LM, Tang MQ, et al. Analysis of the results of the anxiety self-assessment scale in 2462 adolescents. *Chin J Mental Health*. 1997;(02):12–14.
38. Liu X, Tang M. Reliability and validity of the Pittsburgh Sleep Quality Index. *Chin J Psychiatry*. 1996;29:103–107.
39. Qiu WF, Ma JP, Xie ZY, et al. Online risky behavior and sleep quality among Chinese college students: the chain mediating role of rumination and anxiety. *Curr Psychol*. 2022;42(16):13658–13668. doi:10.1007/s12144-021-02641-3
40. Zung WWK. A rating instrument for anxiety disorders. *Psychosomatics*. 1971;12(6):371–379. doi:10.1016/S0033-3182(71)71479-0
41. Tao M, Gao JF. Reliability and validity of the revised self-assessment scale for anxiety (SAS-CR). *Chin J Neuropsych Dis*. 1994;05:301–303.
42. Buysse DJ, Reynolds CF, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh sleep quality index: a new instrument for psychiatric practice and research. *Psychiatry Res*. 1989;28(2):193–213. doi:10.1016/0165-1781(89)90047-4
43. Epskamp S, Waldorp LJ, Mõttus R, Borsboom D. The Gaussian graphical model in cross-sectional and time-series data. *Multivar Behav Res*. 2018;53(4):453–480. doi:10.1080/00273171.2018.1454823
44. Chen J, Chen Z. Extended Bayesian information criteria for model selection with large model spaces. *Biometrika*. 2008;95(3):759–771. doi:10.1093/biomet/asn034
45. Foygel R, Drton M. Extended Bayesian information criteria for Gaussian graphical models. *Adv Neural Inf Process Syst*. 2010;23:2020–2028.
46. Epskamp S, Borsboom D, Fried EI. Estimating psychological networks and their accuracy: a tutorial paper. *Behav Res Methods*. 2018;50(1):195–212. doi:10.3758/s13428-017-0862-1
47. Mullarkey MC, Marchetti I, Beevers CG. Using network analysis to identify central symptoms of adolescent depression. *J Clin Child Adolesc Psychol*. 2019;48(4):656–668. doi:10.1080/15374416.2018.1437735

48. Jones PJ, Ma R, McNally RJ. Bridge centrality: a network approach to understanding comorbidity. *Multivar Behav Res*. 2019;56(2):353–367. doi:10.1080/00273171.2019.1614898
49. Robinaugh DJ, Millner AJ, McNally RJ. Identifying highly influential nodes in the complicated grief network. *J Abnorm Psychol*. 2016;125 (6):747–757. doi:10.1037/abn0000181
50. Jones PJ, Ma R, McNally RJ. Bridge centrality: a network approach to understanding comorbidity. *Multivariate Behav Res*. 2021;56(2):353–367.
51. Borsboom D, Robinaugh DJ, Psychosystems G, Rhemtulla M, Cramer AOJ. Robustness and replicability of psychopathology networks. *World Psychiatry*. 2018;17(2):143–144. doi:10.1002/wps.20515
52. Daniel LC, Wang M, Mulrooney DA, et al. Sleep, emotional distress, and physical health in survivors of childhood cancer: a report from the childhood cancer survivor study. *Psychooncology*. 2019;28(4):903–912. doi:10.1002/pon.5040
53. Okajima I, Akitomi J, Kajiyama I, Ishii M, Murakami H, Yamaguchi M. Effects of a tailored brief behavioral therapy application on insomnia severity and social disabilities among workers with insomnia in Japan: a randomized clinical trial. *JAMA Network Open*. 2020;3(4):e202775. doi:10.1001/jamanetworkopen.2020.2775
54. Chueh KH, Guilleminault C, Lin CM. Alcohol consumption as a moderator of anxiety and sleep quality. *J Nurs Res*. 2019;27(3):e23. doi:10.1097/jnr.0000000000000300
55. Jamieson D, Shan Z, Lagopoulos J, Hermens DF. The role of adolescent sleep quality in the development of anxiety disorders: a neurobiologically-informed model. *Sleep Med Rev*. 2021;59:101450. doi:10.1016/j.smrv.2021.101450
56. Ramsawh HJ, Stein MB, Belik SL, Jacobi F, Sareen J. Relationship of anxiety disorders, sleep quality, and functional impairment in a community sample. *J Psychiatr Res*. 2009;43(10):926–933. doi:10.1016/j.jpsychires.2009.01.009
57. Fissler M, Quante A. A case series on the use of lavendula oil capsules in patients suffering from major depressive disorder and symptoms of psychomotor agitation, insomnia and anxiety. *Compl Ther Med*. 2014;22(1):63–69. doi:10.1016/j.ctim.2013.11.008
58. Sateia MJ. International classification of sleep disorders-third edition. *Chest*. 2014;146(5):1387–1394. doi:10.1378/chest.14-0970
59. Johnson EO, Roth T, Breslau N. The association of insomnia with anxiety disorders and depression: exploration of the direction of risk. *J Psychiatr Res*. 2006;40(8):700–708. doi:10.1016/j.jpsychires.2006.07.008
60. Chen J, Tuersun Y, Yang J, et al. Association of depression symptoms and sleep quality with state-trait anxiety in medical university students in Anhui Province, China: a mediation analysis. *BMC Med Educ*. 2022;22(1):627. doi:10.1186/s12909-022-03683-2
61. Yu C, Liu Z, Su T, et al. The effect of anxiety on sleep disorders in medical students: a moderated mediation model. *Front Psychol*. 2024;15:1338796. doi:10.3389/fpsyg.2024.1338796
62. Alvaro PK, Roberts RM, Harris JK. A systematic review assessing bidirectionality between sleep disturbances, anxiety, and depression. *Sleep*. 2013;36(7):1059–1068. doi:10.5665/sleep.2810
63. Huang B, Yan H, Hu L, et al. The contribution of psychological distress to resting palpitations in patients who recovered from severe COVID-19. *Int J Gen Med*. 2021;14:9371–9378. doi:10.2147/IJGM.S334715
64. Sayar N, Yanartaş Ö, Tigen K, et al. Depression, anxiety, alexithymia and somatosensory sensitivity in patients with benign palpitation. *Psychiatry Clin Psychopharmacol*. 2017;27(2):139–142. doi:10.1080/24750573.2017.1328095
65. Reed DL, Sacco WP. Measuring sleep efficiency: what should the denominator be? *J Clin Sleep Med*. 2016;12(02):263–266. doi:10.5664/jcsm.5498
66. Patriarca GC, Rey Y, Yeguez CE, Buitron V, McMakin DL, Pettit JW. Attentional control accounts for the association between anxiety sensitivity and sleep efficiency in clinic-referred youth. *Child Psychiatry Hum Dev*. 2023. doi:10.1007/s10578-023-01631-9
67. Stein MB, Sareen J. Clinical practice. Generalized anxiety disorder. *N Engl J Med*. 2015;373:2059–2068.
68. Wiltink J, Tschan R, Michal M, et al. Dizziness: anxiety, health care utilization and health behavior – results from a representative German community survey. *J Psychosom Res*. 2009;66(5):417–424. doi:10.1016/j.jpsychores.2008.09.012
69. Lukowski AF, Milojevich HM. Sleep quality and temperament among university students: differential associations with nighttime sleep duration and sleep disruptions. *Behav Sleep Med*. 2014;13(3):217–230. doi:10.1080/15402002.2013.855214
70. Li M, Su H, Liao Z, et al. Gender differences in mental health disorder and substance abuse of Chinese international college students during the COVID-19 pandemic. *Front Psychiatry*. 2021;12:710878.
71. Neubauer DN. New and emerging pharmacotherapeutic approaches for insomnia. *Int Rev Psychiatry*. 2014;26:214–224.
72. Kamei C. Effects of histamine and related compounds on the central nervous system. *Yakugaku Zasshi*. 2021;141:93–110.
73. Bruni O, Angriman M, Melegari MG, Ferri R. Pharmacotherapeutic management of sleep disorders in children with neurodevelopmental disorders. *Expert Opin Pharmacother*. 2019;20(18):2257–2271. doi:10.1080/14656566.2019.1674283
74. Gao R, Lv Y, Li X, et al. Effects of comprehensive sleep management on sleep quality in university students in mainland China. *Sleep Biol Rhythms*. 2014;12(3):194–202. doi:10.1111/sbr.12063
75. Gulia KK, Kumar VM. Importance of sleep for health and wellbeing amidst COVID-19 pandemic. *Sleep Vigil*. 2020;4(1):49–50. doi:10.1007/s41782-020-00087-4
76. Batra K, Sharma M, Batra R, Singh TP, Schvaneveldt N. Assessing the psychological impact of COVID-19 among college students: an evidence of 15 countries. *Healthcare*. 2021;9:222.
77. Becker SP, Jarrett MA, Luebbe AM, Garner AA, Burns GL, Kofler MJ. Sleep in a large, multi-university sample of college students: sleep problem prevalence, sex differences, and mental health correlates. *Sleep Health*. 2018;4(2):174–181. doi:10.1016/j.sleh.2018.01.001
78. Wang F, É B. Determinants of sleep quality in college students: a literature review. *Explore*. 2021;17:170–177.
79. Yang CM, Hung CY, Lee HC. Stress-related sleep vulnerability and maladaptive sleep beliefs predict insomnia at long-term follow-up. *J Clin Sleep Med*. 2014;10(09):997–1001. doi:10.5664/jcsm.4036
80. Mattila E, Peltokoski J, Neva MH, Kaunonen M, Helminen M, Parkkila A-K. COVID-19: anxiety among hospital staff and associated factors. *Ann Med*. 2021;53(1):237–246. doi:10.1080/07853890.2020.1862905
81. Chen J, Wu R. Relations of sleep quality to depression and anxiety in college students. *Chin J Health Psychol*. 2021;29:608–614.
82. Beard C, Millner AJ, Forgeard MJC, et al. Network analysis of depression and anxiety symptom relationships in a psychiatric sample. *Psychol Med*. 2016;46:3359–3369.
83. Li J, Luo C, Liu L, et al. Depression, anxiety, and insomnia symptoms among Chinese college students: a network analysis across pandemic stages. *J Affect Disord*. 2024;356:54–63.

84. Christley Y, Duffy T, Martin CR. A review of the definitional criteria for chronic fatigue syndrome. *J Eval Clin Pract*. 2012;18(1):25–31. doi:10.1111/j.1365-2753.2010.01512.x
85. Gandhi KD, Mansukhani MP, Silber MH, Kolla BP. Excessive daytime sleepiness: a clinical review. *Mayo Clin Proc*. 2021;96(5):1288–1301. doi:10.1016/j.mayocp.2020.08.033
86. ter Wolbeek M, van Doornen LJP, Kavelaars A, Tersteeg-Kamperman MDJ, Heijnen CJ. Fatigue, depressive symptoms, and anxiety from adolescence up to young adulthood: a longitudinal study. *Brain Behav Immun*. 2011;25(6):1249–1255. doi:10.1016/j.bbi.2011.04.015
87. Kim SJ, Kim S, Jeon S, Leary EB, Barwick F, Mignot E. Factors associated with fatigue in patients with insomnia. *J Psychiatr Res*. 2019;117:24–30.
88. American Psychiatry Association. Diagnostic and statistical manual of mental disorders: DSM-5. *Amer Psych Publish*. 2013.
89. Zhou SJ, Wang LL, Yang R, et al. Sleep problems among Chinese adolescents and young adults during the coronavirus-2019 pandemic. *Sleep Med*. 2020;74:39–47. doi:10.1016/j.sleep.2020.06.001
90. Pierson-Bartel R, Ujma PP. Objective sleep quality predicts subjective sleep ratings. *Sci Rep*. 2024;14(1):5943. doi:10.1038/s41598-024-56668-0
91. Huang Z, Goparaju B, Chen H, Bianchi MT. Heart rate phenotypes and clinical correlates in a large cohort of adults without sleep apnea. *Nat Sci Sleep*. 2018;10:111–125. doi:10.2147/NSS.S155733