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Sleep Initiation Symptoms and Network-Level Influence in Anxiety–Sleep Symptom Networks

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Article

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Abstract

Background

Anxiety and sleep disturbances frequently co-occur and may reinforce one another through reciprocal symptom interactions. Previous network studies have primarily focused on identifying highly connected symptoms within psychopathology networks. However, symptoms with strong structural connectivity may not necessarily exert the greatest influence on broader symptom organization.

Methods

This study examined anxiety–sleep symptom interactions using a network-based analytical framework integrating structural connectivity and exploratory influence analyses. Item-level symptom data from adults with mild anxiety and sleep disturbances were used to estimate a regularized symptom network based on Gaussian graphical modeling. Exploratory influence analyses were subsequently performed to examine how hypothetical symptom perturbations were associated with changes in overall network organization.

Results

Excessive worry and difficulty initiating sleep emerged as highly connected symptoms within the estimated network. However, symptoms with the strongest structural connectivity were not always those associated with the largest changes in overall network organization. In particular, difficulty initiating sleep demonstrated relatively high exploratory influence despite only moderate structural connectivity. Exploratory sensitivity analyses further suggested that sleep-related symptoms may play an important role in broader anxiety–sleep symptom interactions.

Conclusions

These findings suggest that structural connectivity and exploratory influence may represent partially distinct characteristics within anxiety–sleep symptom systems. Integrating exploratory influence analyses with conventional network approaches may provide additional perspectives for understanding symptom interactions in co-occurring anxiety and sleep disturbances.

1. Introduction

Anxiety and sleep disturbances are among the most prevalent psychological symptoms in both clinical and community settings. These symptoms frequently co-occur and often interact in ways that reinforce one another over time (Alvaro et al., 2013; Baglioni et al., 2011). Persistent worry, cognitive hyperarousal, and emotional tension may interfere with sleep initiation and maintenance, whereas repeated sleep

disruption and insufficient sleep can intensify anxiety symptoms during subsequent days (Harvey, 2002; Cox and Olatunji, 2020). Through these reciprocal interactions, anxiety and sleep-related symptoms may become chronic and increasingly difficult to manage clinically.

Recent psychopathology research has increasingly conceptualized mental health symptoms as interconnected systems rather than as passive indicators of underlying disorders (Borsboom and Cramer, 2013; Fried et al., 2017). Within this framework, network analysis approaches model symptoms as interacting components that collectively form the structure of psychopathology (Borsboom, 2017, Robinaugh et al., 2020; McNally, 2021). Such approaches allow researchers to examine direct relationships among symptoms and to identify patterns of symptom interaction that may contribute to the persistence of psychological distress.

Previous network studies involving anxiety and sleep disturbances have primarily focused on identifying "central symptoms," defined as symptoms that exhibit relatively strong or numerous connections within the network (Jones et al., 2021; Beard et al., 2016). Centrality metrics provide useful information regarding the structural importance of individual symptoms. However, symptoms with the strongest connectivity are not always those most strongly associated with broader changes across the network structure. Some highly connected symptoms may have relatively limited influence on the overall organization of the network, whereas symptoms with fewer direct connections may still be associated with broader network-level changes (Epskamp and Isvoranu, 2022; Fried and Cramer, 2017).

From this perspective, symptom networks may also be explored using analytical approaches that examine potential influence patterns beyond traditional connectivity measures. In interconnected symptom systems, perturbations associated with specific symptoms may propagate through the network and relate to broader changes in symptom organization. Examining these influence patterns may therefore provide additional insight into how anxiety and sleep symptoms interact within broader psychopathology structures.

Accordingly, the present study examined anxiety–sleep symptom interactions using a network-based analytical framework integrating structural connectivity measures with exploratory influence analyses. Particular attention was given to whether symptoms showing strong structural connectivity also demonstrated broader influence on overall symptom network organization. Rather than focusing solely on structural connectivity, this study explored how perturbations associated with individual symptoms were related to broader changes in estimated network organization under a simplified mathematical framework. By integrating traditional network metrics with exploratory influence analyses, this study aimed to provide a broader understanding of symptom interaction patterns in co-occurring anxiety and sleep disturbances.

2. Methods

2.1 Study Design and Participants

This study employed a cross-sectional network design to examine interactions between anxiety and sleep symptoms. Participants were adults reporting at least mild anxiety and sleep disturbance symptoms who were recruited through a community-based online survey platform in South Korea between January and December 2025. The sample should therefore be considered a community-based convenience sample rather than a nationally representative population.

Eligibility criteria were: (1) age between 18 and 65 years, (2) a score of 5 or higher on the Generalized Anxiety Disorder scale (GAD-7), and (3) a score of 8 or higher on the Insomnia Severity Index (ISI). Individuals with current psychotic disorders, bipolar disorder, neurological disorders, or substance use disorders were excluded.

This study was approved by the Institutional Review Board of Public Institutional Review Board designated by the Korea National Institute for Public Health Policy (IRB No. KoDac1035C1), and written informed consent was obtained from all participants prior to participation. All methods were performed in accordance with the relevant guidelines and regulations. Missing data were minimal (< 1%) and were handled using pairwise deletion during network estimation.

2.2 Symptom-Level Network Construction

In this study, 14 item-level nodes were defined using individual items from the GAD-7 and ISI. Using item-level symptoms rather than total scale scores allowed the analysis to examine direct relationships among specific symptoms within the network. Node importance was primarily assessed using strength centrality.

To estimate the symptom network, a Gaussian graphical model (GGM) with graphical LASSO regularization was applied. The extended Bayesian information criterion (EBIC; $\gamma = 0.5$) was used for network regularization. Because GAD-7 and ISI items are ordinal variables, a polychoric correlation matrix was estimated prior to network estimation. The network structure was estimated using the EBICglasso procedure. Network accuracy and stability were evaluated using 1,000 nonparametric bootstrap iterations.

2.3 Network Dynamics and Stability Metrics

In addition to examining structural relationships among symptoms, network-level characteristics were explored using several global network indices. The weighted adjacency matrix derived from the estimated symptom network was used to examine overall patterns of symptom connectivity and exploratory network sensitivity.

Several global network indices were additionally calculated to examine broader network organization and sensitivity patterns within the estimated symptom structure.

Global network energy was calculated as:

$$E=\sum_{i<j} w^2_{ij}$$

where w_{ij} represents the estimated edge weight between symptom nodes *i* and *j*. In the present study, this metric was used as a summary index reflecting the overall magnitude of symptom connectivity within the estimated network structure.

2.4 Centrality and Exploratory Influence Estimation

Strength centrality was used as the primary measure of node importance within the symptom network. Strength centrality represents the sum of the absolute edge weights connected to each symptom node and reflects the overall degree of symptom connectivity within the network. Expected influence was additionally calculated because it considers both the magnitude and direction of network connections.

To complement traditional centrality measures, this study additionally explored broader symptom influence patterns using exploratory network influence analyses. Exploratory influence values were estimated to examine the relative influence of individual symptoms on broader network-level indices within the estimated symptom structure (Gu et al., 2015; Pan et al., 2024).

Importantly, the present analysis was based on a cross-sectional Gaussian graphical model and does not represent temporal or causal symptom dynamics. Accordingly, the controllability-informed analysis should be interpreted as an exploratory mathematical approximation of potential influence patterns within the estimated symptom network.

2.5 Exploratory Network Perturbation Analysis

To further examine potential differences between structural connectivity and broader network influence, an exploratory perturbation analysis was conducted. In this analysis, proportional reductions were applied to network connections associated with individual symptoms, and changes in network-level indices were subsequently evaluated.

Specifically, a 30% proportional reduction was applied to the weighted connections associated with each symptom node within the estimated adjacency matrix. Following this modification, global network indices, including spectral radius and global network energy, were recalculated to examine relative changes in overall network organization.

Symptoms associated with larger changes in network-level indices following perturbation were interpreted as showing relatively greater influence within the estimated network structure. To compare different patterns of symptom importance, symptoms ranked highly on traditional centrality indices were also compared with those showing relatively high exploratory influence values. Because empirically established thresholds for symptom-level perturbation are currently unavailable, the 30% reduction parameter was selected as an exploratory analytical condition rather than as a clinically validated intervention threshold. Additional sensitivity analyses using alternative perturbation magnitudes (10%, 20%, and 40%) were also conducted to examine the relative consistency of the observed network patterns.

The present perturbation analysis should be interpreted as an exploratory evaluation of hypothetical network sensitivity within the estimated symptom structure rather than as a simulation of real clinical intervention effects.

2.6 Statistical Analysis

All statistical analyses were conducted using R software (version 4.3.2). The symptom network was estimated using the qgraph, bootnet, and glmnet packages. Bootstrap procedures with 1,000 iterations were performed to evaluate network accuracy and the stability of centrality estimates. The correlation stability coefficient (CS coefficient) was additionally calculated to assess the robustness of centrality indices. Sensitivity analyses under alternative perturbation magnitudes were also conducted to examine the relative consistency of the observed network patterns.

3. Results

3.1 Baseline Characteristics

A total of 759 participants were included in the analysis. The mean age was 34.8 years (SD = 9.6), and 62.4% of participants were women. The mean GAD-7 score was 8.41 (SD = 3.12), and the mean ISI score was 11.27 (SD = 3.54), indicating generally mild levels of anxiety and insomnia symptoms within the sample. Additional participant characteristics are presented in Table 1. GAD-7 and ISI total scores were moderately correlated ($r = 0.48$, $p < .001$), indicating that higher anxiety levels were associated with greater sleep disturbance.

Table 1
Participants Characteristics (N = 759)

Variables	Total Sample (n = 759)
Age (years), Mean (SD)	34.8 (9.6)
Female, n (%)	474 (62.4)
Education ($\geq$ College), n (%)	512 (67.5)
Employed, n (%)	421 (55.5)
GAD-7 total score, Mean (SD)	8.41 (3.12)
Mild anxiety (5–9), n (%)	498 (65.6)
Moderate or higher anxiety (≥ 10), n (%)	261 (34.4)
ISI total score, Mean (SD)	11.27 (3.54)
Mild insomnia (8–14), n (%)	533 (70.2)
Moderate or higher insomnia (≥ 15), n (%)	226 (29.8)

Note: Values are presented as mean ± standard deviation unless otherwise indicated. GAD-7 = Generalized Anxiety Disorder-7; ISI = Insomnia Severity Index.

3.2. Network Structure of Anxiety–Sleep Symptoms

The estimated symptom network contained five non-zero edges among anxiety and sleep symptoms (Fig. 1). Edge weights ranged from 0.27 to 0.41. The strongest association was observed between “excessive worry” (GAD3) and “tension” (GAD4) (r = 0.41). A relatively strong association was also identified between “difficulty falling asleep” (ISI1) and “difficulty maintaining sleep” (ISI2) (r = 0.37). In addition, a cross-domain association was observed between “excessive worry” (GAD3) and “difficulty falling asleep” (ISI1) (r = 0.31), linking anxiety and sleep symptoms within the network.

Node size in Fig. 1 reflects strength centrality values. “Excessive worry” (GAD3) and “difficulty falling asleep” (ISI1) showed the highest strength centrality within the estimated network.

Note

Blue nodes represent anxiety symptoms from the Generalized Anxiety Disorder-7 (GAD-7), and orange nodes represent insomnia symptoms from the Insomnia Severity Index (ISI). Edges represent regularized partial correlations after controlling for all other nodes in the network. Thicker edges indicate stronger associations between symptoms. Node size reflects strength centrality values within the estimated network.

3.3. Comparison Between Strength Centrality and Exploratory Influence

Strength centrality values ranged from 0.22 to 1.82. The highest centrality value was observed for “excessive worry” (GAD3) (1.82), followed by “difficulty falling asleep” (ISI1) (1.55), indicating that these symptoms showed the strongest overall connectivity within the network.

When strength centrality was compared with exploratory influence values (Fig. 2), the relationship between the two measures was not strictly proportional. Although GAD3 showed the highest structural centrality, several sleep-related symptoms demonstrated relatively higher exploratory influence values.

In particular, “difficulty falling asleep” (ISI1) showed both high strength centrality and high exploratory influence values. In addition, “difficulty maintaining sleep” (ISI2) demonstrated relatively high exploratory influence despite moderate strength centrality. These findings suggest that symptoms with the strongest connectivity were not always those most strongly associated with broader changes in network-level indices. Sleep-related symptoms showed comparatively broader variability in exploratory influence values despite moderate structural connectivity.

Bootstrap-based stability analysis indicated adequate stability of the estimated centrality metrics (CS coefficient > 0.50). Difference tests additionally showed that the highest-ranked centrality nodes differed significantly from most lower-ranked nodes.

Note

Each point represents an individual symptom from the GAD-7 (blue) or ISI (orange). The x-axis represents strength centrality, and the y-axis represents standardized exploratory influence values. Dashed lines indicate the mean centrality value and the reference value of zero.

3.4. Exploratory Influence Analysis

Exploratory influence values varied across symptoms (Fig. 3). The highest value was observed for “difficulty falling asleep” (ISI1) (z = 1.65), followed by “excessive worry” (GAD3) (z = 1.48). These findings suggest that these symptoms were relatively more strongly associated with broader changes in network-level indices within the estimated symptom structure.

Moderate exploratory influence values were observed for “tension” (GAD4, z = 0.72) and “difficulty maintaining sleep” (ISI2, z = 0.65). In contrast, “early morning awakening” (ISI7, z = − 1.02), ISI6 (z = − 0.88), GAD1 (z = − 0.74), and GAD5 (z = − 0.62) showed comparatively lower exploratory influence values.

Importantly, the ranking of exploratory influence values did not fully correspond to the ranking of strength centrality. Although GAD3 showed high values for both indices, several sleep-related symptoms demonstrated relatively high exploratory influence despite moderate structural connectivity. These

findings suggest that structural connectivity and exploratory influence metrics may capture different aspects of symptom network organization.

Note

Exploratory influence values across anxiety–sleep symptoms. Each bar represents the standardized exploratory influence value (z-score) for an individual symptom node within the estimated anxiety–sleep symptom network. Nodes are ordered from the highest to the lowest exploratory influence values. The dashed vertical line indicates the reference value of zero. Higher values indicate relatively greater influence within the estimated network structure.

3.5. Changes in Network-Level Indices Following Exploratory Perturbation

Exploratory perturbation analysis was conducted to examine changes in network-level indices following proportional reductions in symptom-related edge weights (Table 2). A 30% reduction was applied to symptoms showing the highest exploratory influence values (ISI1, GAD3, and GAD4). For comparison, the same reduction was additionally applied to symptoms with the highest strength centrality values (GAD3, ISI1, and GAD4).

When perturbation was prioritized based on exploratory influence values, global network strength decreased from 6.84 to 5.35 (− 21.8%). In contrast, perturbation based on strength centrality reduced global network strength from 6.84 to 6.07 (− 11.2%). Similarly, global efficiency increased from 0.41 to 0.49 (+ 18.9%) under exploratory influence-based perturbation, whereas a smaller increase was observed under centrality-based perturbation (0.41 to 0.43; +4.9%).

Overall, larger changes in network-level indices were observed when symptoms were selected according to exploratory influence values rather than strength centrality. Similar ranking patterns were observed across alternative perturbation magnitudes (10%, 20%, and 40%), supporting the relative consistency of the observed findings. These results should be interpreted as exploratory analyses of hypothetical network sensitivity within the estimated symptom structure rather than as estimates of real clinical intervention effects.

Table 2
Changes in network-level indices following exploratory perturbation analysis

Targeting Strategy	Centrality-Based Targeting	Exploratory Influence-Based Targeting
Global Strength (Baseline)	6.84	6.84
Global Strength (Post)	6.07	5.35
Δ Strength (%)	-11.2%	-21.8%
Global Efficiency (Baseline)	0.41	0.41
Global Efficiency (Post)	0.43	0.49
Δ Efficiency (%)	+ 4.9%	+ 18.9%

Note. Network-level indices were recalculated after applying a proportional 30% reduction to edge weights associated with targeted symptoms. Values reflect exploratory changes within the estimated network structure under hypothetical perturbation conditions.

4. Discussion

The present study examined anxiety–sleep symptom interactions using a network-based analytical framework integrating structural connectivity measures with exploratory influence analyses. Several findings merit discussion. First, although excessive worry and sleep-initiation difficulty emerged as highly connected symptoms within the estimated network, the ranking of exploratory influence values did not fully correspond to traditional centrality rankings. Second, sleep-related symptoms, particularly difficulty falling asleep, demonstrated relatively high exploratory influence values despite only moderate structural connectivity. Third, exploratory perturbation analyses showed that symptom selection based on exploratory influence values was associated with larger changes in network-level indices than symptom selection based solely on strength centrality. Together, these findings suggest that symptom connectivity and broader influence patterns may represent partially distinct characteristics within anxiety–sleep symptom networks.

Consistent with previous psychopathology network studies, excessive worry and tension emerged as strongly connected symptoms within the anxiety cluster, whereas difficulty falling asleep and difficulty maintaining sleep showed relatively strong within-domain associations in the insomnia cluster. Similar patterns have been reported in previous network studies examining anxiety, insomnia, and depressive symptoms, where cognitive hyperarousal and persistent worry were identified as important bridge components linking emotional distress and sleep disturbance (Cai et al., 2022; Chen et al., 2025; Kaiser et al., 2021; Liao et al., 2026; Liu et al., 2025). The cross-domain association observed between excessive worry and difficulty falling asleep in the present network further supports the possibility that

anxiety and sleep symptoms reinforce one another through reciprocal symptom interactions rather than through isolated symptom processes.

An important finding of the present study was that the symptoms with the strongest structural connectivity were not always those showing the highest exploratory influence values. Although excessive worry demonstrated the highest strength centrality, difficulty falling asleep showed the highest exploratory influence value and was associated with comparatively larger changes in network-level indices during perturbation analyses. This distinction suggests that structurally central symptoms and symptoms associated with broader network sensitivity may not necessarily overlap completely. Previous methodological work has similarly suggested that centrality metrics alone may not fully identify clinically meaningful intervention targets within psychopathology networks (Castro et al., 2024; Schumacher et al., 2024; Wang et al., 2022). In practical terms, some symptoms may occupy highly connected positions within a network while exerting relatively limited influence on broader changes in network organization.

The prominence of sleep-initiation difficulty across multiple analyses may have particular clinical relevance. Difficulty initiating sleep is closely associated with cognitive rumination, emotional hyperarousal, anticipatory anxiety, and autonomic activation, all of which are recognized mechanisms contributing to anxiety maintenance and chronic insomnia. Previous network studies have also identified insomnia-related symptoms as important bridge components linking emotional distress with broader psychopathology (Huang et al., 2025; Yuan et al., 2025; Jin et al., 2023).

Because sleep initiation lies at the intersection of emotional regulation and physiological arousal processes, disturbances in this domain may be associated with broader symptom interactions across both anxiety and insomnia networks. In the present study, ISI1 demonstrated not only relatively strong structural connectivity but also the highest exploratory influence value, suggesting that sleep-initiation symptoms may occupy a particularly influential position within anxiety–sleep symptom organization.

Another notable observation was the relative variability of exploratory influence values among sleep-related symptoms. Whereas several anxiety symptoms clustered around moderate influence values, insomnia symptoms demonstrated broader dispersion across the influence spectrum. For example, difficulty initiating sleep and difficulty maintaining sleep showed relatively high exploratory influence values, whereas early morning awakening demonstrated comparatively lower values. This pattern may indicate that insomnia symptoms differ substantially in their relationships with broader symptom organization despite belonging to the same clinical domain. Previous studies examining insomnia-related symptom networks have likewise reported substantial heterogeneity in the functional roles of individual sleep symptoms within psychopathology networks (Blanken et al., 2020; Xi et al., 2025).

The exploratory perturbation analyses further supported these observations. When perturbation conditions were applied according to exploratory influence rankings, larger reductions in global network strength and larger increases in global efficiency were observed compared with perturbations based on strength centrality alone. Although these findings should not be interpreted as direct estimates of treatment effects, they suggest that exploratory influence metrics may provide additional information

beyond conventional structural centrality measures. Similar ranking patterns were also observed across alternative perturbation magnitudes, supporting the relative consistency of the observed network patterns under different hypothetical conditions. Recent simulation-based psychopathology network studies have similarly suggested that intervention prioritization based solely on structural connectivity may not fully capture broader symptom-level influence patterns (Li et al., 2024; Lunansky et al., 2022).

Several limitations should be considered when interpreting these findings. First, the symptom network was estimated using cross-sectional data, and therefore causal or temporal conclusions cannot be inferred. The Gaussian graphical model used in the present study reflects conditional associations observed at a single time point and does not represent temporal symptom transitions or causal dynamics. Recent methodological studies have emphasized the importance of avoiding causal interpretations of cross-sectional psychopathology networks and cautioned against directly inferring dynamic processes from undirected network structures (Hallquist et al., 2021; Dablander and Hinne, 2019). Second, all measures were based on self-reported symptoms, which may be influenced by reporting bias, recall bias, or individual differences in symptom perception. Third, the exploratory influence analyses relied on simplified mathematical approximations of symptom interactions. Psychological symptom systems are likely to involve nonlinear and time-varying processes that cannot be fully captured using the present framework.

Several methodological limitations also warrant consideration. The perturbation procedure involved proportional modification of estimated edge weights rather than direct manipulation of symptom severity and should therefore be interpreted as an exploratory sensitivity analysis rather than a clinically validated intervention model. In addition, the estimated network was relatively sparse, which may partly reflect restricted symptom variability within this community-based sample consisting primarily of individuals with mild anxiety and insomnia symptoms. Sparse regularized networks may be more sensitive to estimation variability and threshold effects, and therefore the observed network patterns should be interpreted cautiously. External validation using independent datasets and clinically diagnosed populations was not available in the present study and will be necessary to evaluate the generalizability and reproducibility of the current findings.

Despite these limitations, the present study extends previous anxiety–sleep network research by integrating structural connectivity measures with exploratory influence analyses. Rather than replacing traditional centrality metrics, the present framework may offer a complementary perspective for examining broader symptom influence patterns within psychopathology networks. Future longitudinal and intervention-based studies will be necessary to determine whether symptoms showing relatively high exploratory influence are consistently associated with broader changes in symptom organization and clinical outcomes across diverse populations. Future studies may also benefit from incorporating explainable analytical approaches to improve the interpretability and clinical applicability of network-based influence metrics in psychopathology research.

5. Conclusion

This study examined anxiety and sleep symptoms using a network-based analytical framework integrating structural connectivity measures with exploratory influence analyses. The findings demonstrated that symptoms showing strong structural connectivity were not always those associated with the largest changes in network-level indices under hypothetical perturbation conditions. In particular, several sleep-related symptoms, especially difficulty initiating sleep, demonstrated relatively high exploratory influence despite only moderate structural connectivity within the estimated network.

These results suggest that conventional connectivity metrics alone may not fully characterize the broader network-level roles of individual symptoms in comorbid anxiety and sleep disturbances. The present findings further indicate that combining structural centrality measures with exploratory influence-based approaches may provide a more comprehensive understanding of symptom organization within psychopathology networks.

Importantly, the present exploratory influence framework should be interpreted as a mathematical approximation of symptom interaction patterns rather than as a causal or clinically validated intervention model. Future studies using longitudinal symptom data, temporal network models, and explainable analytical approaches may help clarify the clinical relevance and reproducibility of these network-level influence patterns.

Declarations

CONFLICTS OF INTEREST

The author declares no conflicts of interest.

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Author Contribution

Sanghee Kim conceived the study, designed the data collection protocol, curated and validated the dataset, performed quality control procedures, prepared the metadata, conducted data analyses, and wrote the manuscript.

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Data Availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Figures

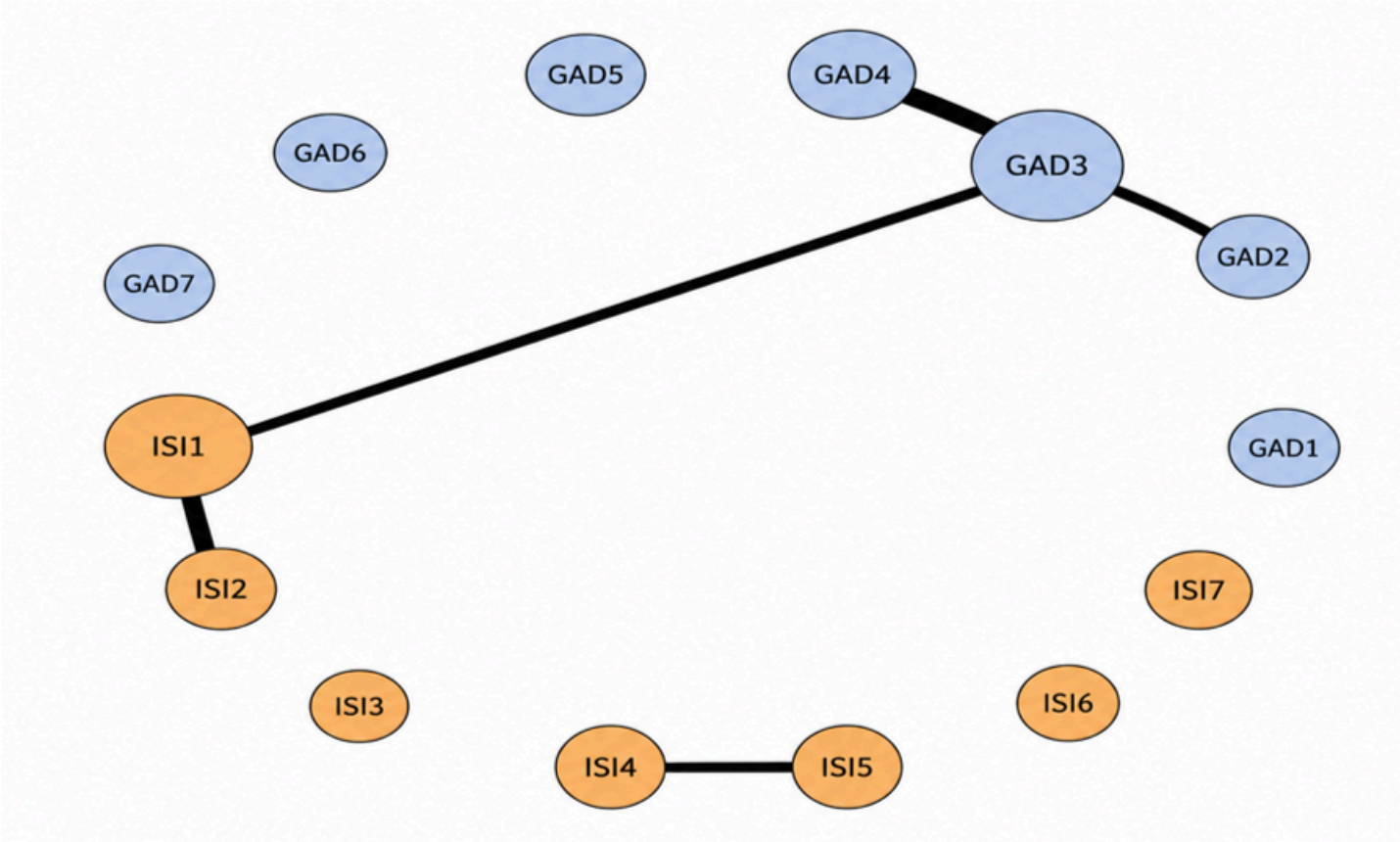


Figure 1

Estimated anxiety–sleep symptom network

Note. Blue nodes represent anxiety symptoms from the Generalized Anxiety Disorder-7 (GAD-7), and orange nodes represent insomnia symptoms from the Insomnia Severity Index (ISI). Edges represent regularized partial correlations after controlling for all other nodes in the network. Thicker edges indicate stronger associations between symptoms. Node size reflects strength centrality values within the estimated network.

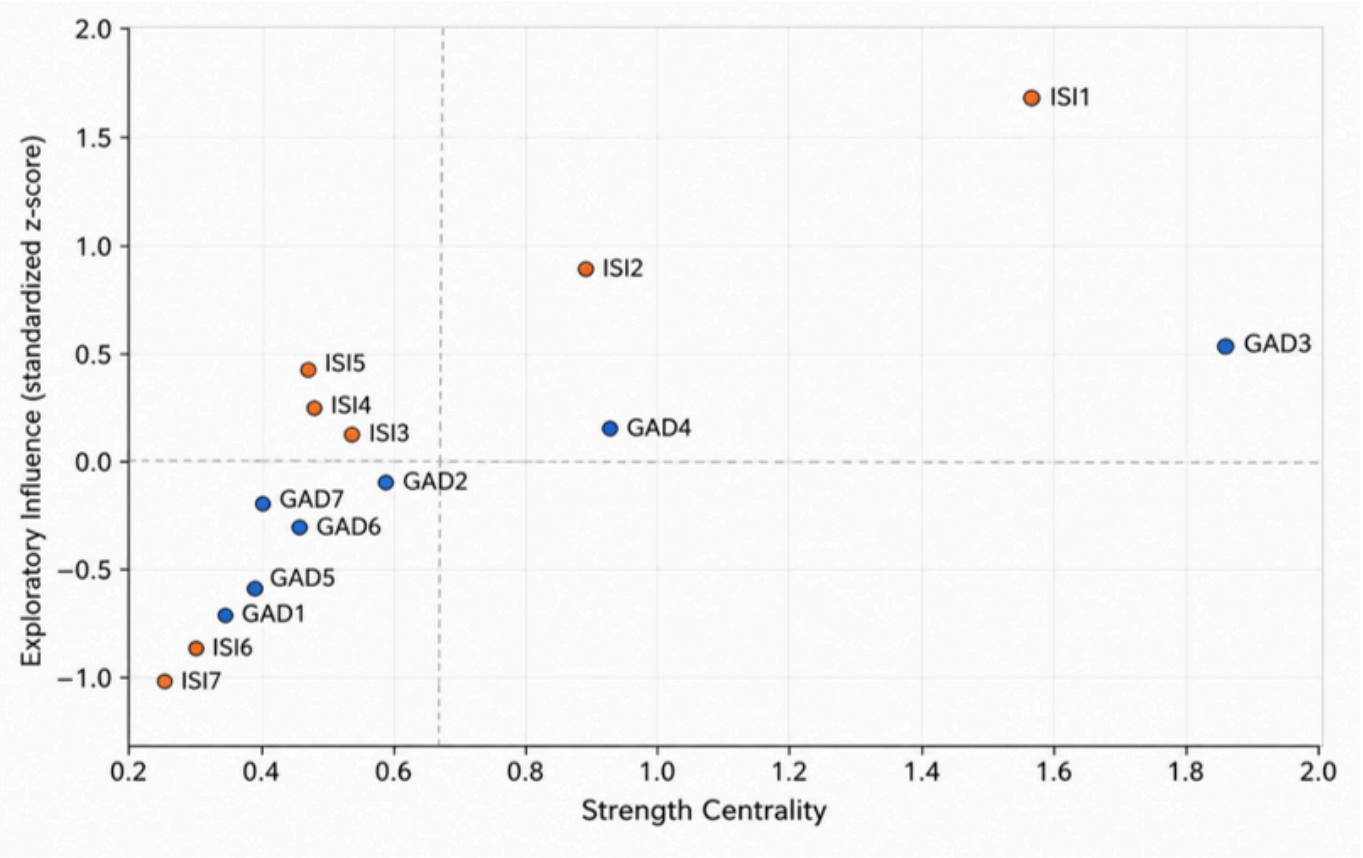


Figure 2

Comparison of strength centrality and exploratory influence values

Note. Each point represents an individual symptom from the GAD-7 (blue) or ISI (orange). The x-axis represents strength centrality, and the y-axis represents standardized exploratory influence values. Dashed lines indicate the mean centrality value and the reference value of zero.

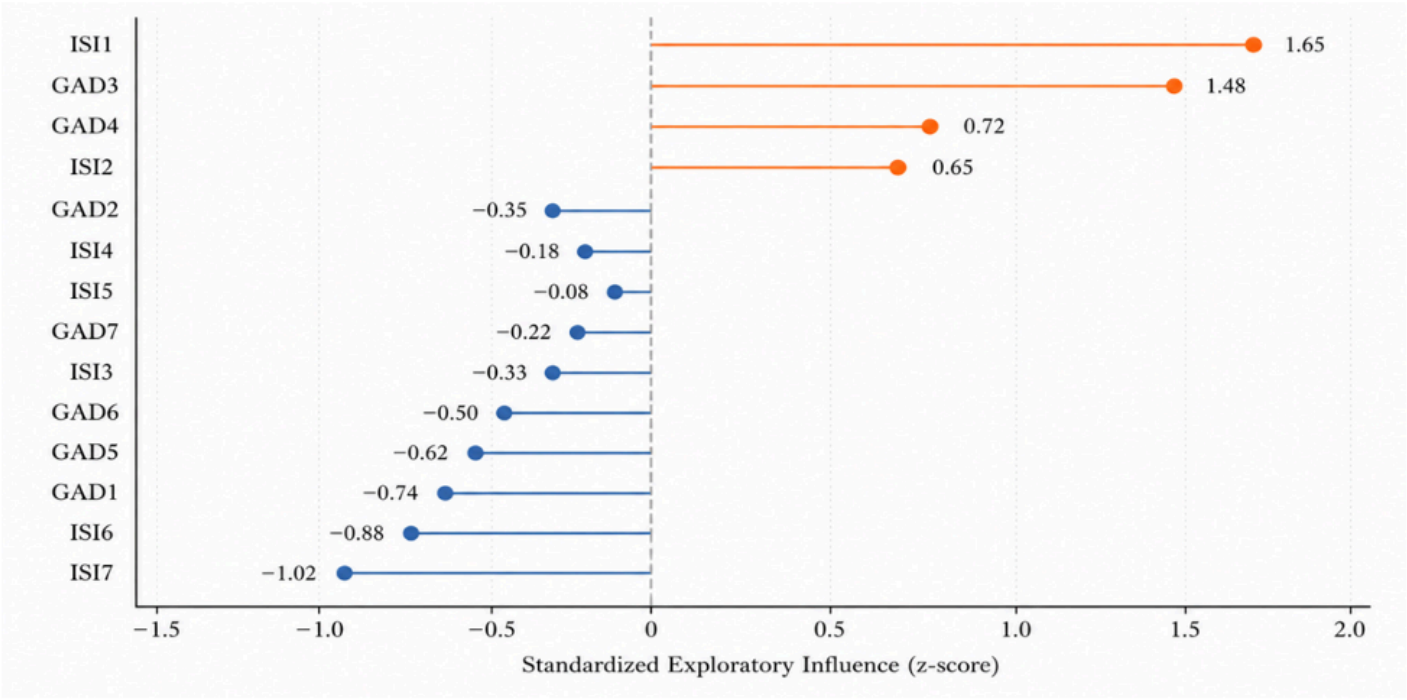


Figure 3

Exploratory influence values across anxiety–sleep symptoms

Note. Exploratory influence values across anxiety–sleep symptoms. Each bar represents the standardized exploratory influence value (z-score) for an individual symptom node within the estimated anxiety–sleep symptom network. Nodes are ordered from the highest to the lowest exploratory influence values. The dashed vertical line indicates the reference value of zero. Higher values indicate relatively greater influence within the estimated network structure.