

Anxiety and depression among Chinese international student-athletes during study abroad: a psychological network approach

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Abstract

Background and Study Aim Depression and anxiety are prevalent mental health challenges among college students. International student-athletes abroad face distinct mental health challenges compared to general students due to their dual roles as athletes and international students. The purpose of this study was to analyze the network structure and characteristics of anxiety and depression in Chinese international student-athletes during study abroad from a network perspective.

Material and Methods A network analysis approach was used in this study. A total of 219 Chinese student-athletes studying in Malaysia were recruited for this research, and their demographic characteristics were collected. The Generalized Anxiety Disorder-7 (GAD-7) and the Patient Health Questionnaire-9 (PHQ-9) were used to assess symptoms of anxiety and depression.

Results The results revealed that the strongest relationship in the network was between psychomotor issues (PHQ8) and self-harming tendencies (PHQ9). Nervousness (GAD1) demonstrated the highest node strength, followed by sleep issues (PHQ3) and guilty feelings (PHQ6). Psychomotor issues (PHQ8) exhibited the highest node expected influence value. Nervousness (GAD1) was identified as the most important bridging symptom. The network demonstrated good accuracy in stability tests. Three symptom communities were identified in the community detection results.

Conclusions This study highlights the importance of addressing mental health concerns among overseas student-athletes. The findings could inform the future design of intervention strategies targeting core symptoms, thereby reducing levels of anxiety and depression among international student-athletes during their studies abroad. Additionally, the network analysis perspective offers new research avenues for studying the unique characteristics of sports groups in the future.

Keywords: anxiety, depression, psychological network analysis, international students, student-athlete.

Introduction

In recent years, depression and anxiety have become increasingly prevalent mental health issues worldwide. The World Health Organization (WHO) estimates that approximately 300 million people globally are affected by depression [1], with the prevalence of anxiety disorders reaching 4.4% [2]. Among university students, the situation is even more alarming. Studies conducted globally on the mental health of college students consistently show that depression and anxiety are prevalent across diverse backgrounds and at varying levels [3, 4]. College students are at high risk for mental health issues due to challenges such as academic pressure, social adjustment, and career planning [5, 6, 7]. Furthermore, depression and anxiety often co-occur and have a compounding effect [8]. Previous research has shown that anxiety increases the risk of depression, and there is a complex relationship between the two in the mental health system [9]. Additionally, mild anxiety and depression are often overlooked, leading to an underestimation of their negative effects [4, 10].

International student-athletes have a dual identity as international students and athletes, which makes the challenges they face more complex. International students often experience serious psychological problems due to language barriers, cultural conflicts, and isolation during adaptation [11, 12, 13]. About half of international students feel anxious and depressed within the first month of their arrival abroad, exacerbating their difficulties with social adjustment [14]. Moreover, uncertainties abroad, such as experiences of discrimination and differences in academic requirements, increase their vulnerability to anxiety and depression [15]. For student-athletes, balancing academic demands with athletic training presents an additional source of stress [16, 17]. In an overseas environment, student-athletes may become frustrated due to communication barriers and difficulties in adapting to their multiple roles [18]. Additionally, differences in local sports culture may lead to periods of depression and adjustment challenges [19].

For Chinese student-athletes, these challenges are particularly pronounced. Many Chinese student-athletes are heavily focused on sports, which often results in a relative educational gap and weaker

academic performance [20]. During the transition to becoming international student-athletes, they frequently face significant uncertainties. For example, Chinese student-athletes in the NCAA have experienced role conflicts due to differing expectations from various stakeholders, lack of academic preparation, and unfamiliarity with the college sports system as they adapt to a foreign education system [21]. Moreover, the transition of athlete identity requires a redefinition of their role, specifically shifting from a performance-oriented athlete to a student-athlete balancing both academic and athletic performance [22, 23]. The uncertainty associated with this role transition often leads to psychosocial issues [24]. However, other studies have shown that they lead healthier lives than their non-athlete peers, particularly exhibiting less depression and anxiety [25]. While student-athletes' lifestyles may be healthier due to their athletic habits [26], the psychosocial challenges they face in adapting to an overseas environment cannot be ignored.

Network analysis methods have been increasingly applied in the fields of education and psychopathology to explore the complex interactions underlying mental health issues [27, 28]. As an emerging research tool, network analysis can reveal the internal dynamics of psychological disorders, particularly the interaction patterns between depression and anxiety [29]. This method treats each symptom as a node in a network and the associations between symptoms as edges, providing a visual representation of the structural characteristics of mental health issues [30]. Compared to traditional research methods based on total scale scores, network analysis offers a more refined perspective, enabling the identification of key symptoms and bridging symptoms [31]. Existing studies indicate that network analysis has high applicability across various mental health issues. For instance, in a study of anxiety and depression symptoms among university students, network analysis identified 'restlessness' and 'motor' as bridging symptoms between depression and anxiety, potentially serving as core factors in their comorbidity [29]. The benefits of network analysis can be extended to multiple aspects of mental health. For example, individuals may experience psychological network effects influenced by symptoms and factors such as adaptation, anxiety, depression, stress, and loneliness [32].

The analysis of existing studies revealed that researchers are primarily concerned with mental health issues among students, particularly anxiety and depression, and their impact on academic and social adaptation. However, despite numerous studies addressing these issues, there is still a clear need for a deeper investigation into the interactions

between symptoms of anxiety and depression, especially in the context of student-athletes studying abroad. This study aimed to systematically reveal the structure and associations of the depression and anxiety network among student-athletes during their study abroad.

Materials and Methods

Participants

To be eligible, participants had to be undergraduate or postgraduate students aged 18 or above with athlete qualifications recognized by the General Administration of Sport of China. This study was approved by the Faculty of Education at the Universiti Kebangsaan Malaysia and included 219 valid responses. All participants completed the questionnaire online and provided electronic written informed consent. They were informed of the purpose and content of the survey. This study group represents a special population and was recruited through snowball sampling within the Chinese overseas online community. The sociodemographic characteristics of the participants are presented in Table 1.

Table 1. Characteristic of Chinese international student-athletes

Characteristic			
Type of sports		n	%
	Ball	77	35.1
	Track and field	102	46.5
	Water sports	8	3.7
	Combat sports	3	1.4
	Dance sports	10	4.6
	Gymnastics	7	3.1
	Strengths sports	12	5.5
Educational level			
	Degree	120	54.7
	Master	42	19.2
	Doctoral	57	26.1
Athlete level*			
	International Elite Athlete	0	0
	Elite Athlete	3	1.4
	Division I	25	11.4
	Division II	161	73.5
	Division III	30	13.7
Gender			
	Male	131	59.8
	Female	88	40.2

Note. *Athletic levels are based on the standards of the General Administration of Sport of China.

The data presented in Table 1 highlight the predominance of track and field sports among participants and a higher representation of male athletes. Most participants were Division II athletes and pursuing undergraduate degrees. Additionally, only a small proportion of participants were engaged in elite-level competitions or non-traditional sports categories, reflecting the diverse but skewed distribution of athletic levels and types of sports.

Research Design

This is a cross-sectional study based on a questionnaire survey conducted between October 15, 2024, and November 15, 2024, targeting Chinese student-athletes studying in Malaysia. The study primarily utilized the Generalized Anxiety Disorder Scale (GAD-7) [33] to measure anxiety levels among Chinese international student-athletes, with the item references shown in Table 1. The GAD-7 is a four-point Likert scale, with item scores ranging from 0 (not at all) to 3 (nearly every day). Higher scores indicate more severe anxiety symptoms. Similarly, the Patient Health Questionnaire-9 (PHQ-9) [34] was employed to measure depression levels, with the item references also shown in Table 1. The PHQ-9 is a four-point Likert scale, with scores for each item ranging from 0 (not at all) to 3 (nearly every day), and higher scores reflecting greater symptom severity. The Chinese versions of the questionnaires have demonstrated reliability and validity [35].

Statistical Analysis

All data cleaning and network analysis were performed using the R program. Network analysis was conducted in three areas: network estimation, network stability, and network communities.

The network was constructed by representing each item as a node and the associations between

nodes as edges, estimated through partial correlation analysis while controlling for confounding effects. Nonparametric correlations were calculated using a nonparanormal transformation to address the uneven distribution of item scores. The Least Absolute Shrinkage and Selection Operator (LASSO) with the Extended Bayesian Information Criterion (EBIC) ensured a sparse and interpretable network [36, 37]. Network estimation and visualization were conducted using the bootnet and qgraph packages in R, with edge thickness representing the strength of associations (green for positive and red for negative) [30].

Centrality indices (strength, expected influence, betweenness, and closeness) were computed using the qgraph package, focusing on strength as the most robust measure. Node predictability was calculated using the mgm package [37, 38]. Bridge strength, reflecting the role of nodes in linking anxiety and depression, was analyzed using the networktools package [31].

Stability of node and bridge strength was evaluated via case-dropping bootstrap procedures, ensuring reliability with CS-C values above 0.25 and confidence intervals calculated using the bootnet package [39, 40]. Community detection was performed with the Spin Glass algorithm implemented in the igraph package, which identifies densely connected communities within the network [41].

Results

Figure 1 illustrates the network structure of anxiety and depressive symptoms among Chinese international student-athletes. Key connections include Psychomotor issues-Self-harming tendencies (PHQ8-PHQ9), Sleep-Fatigue

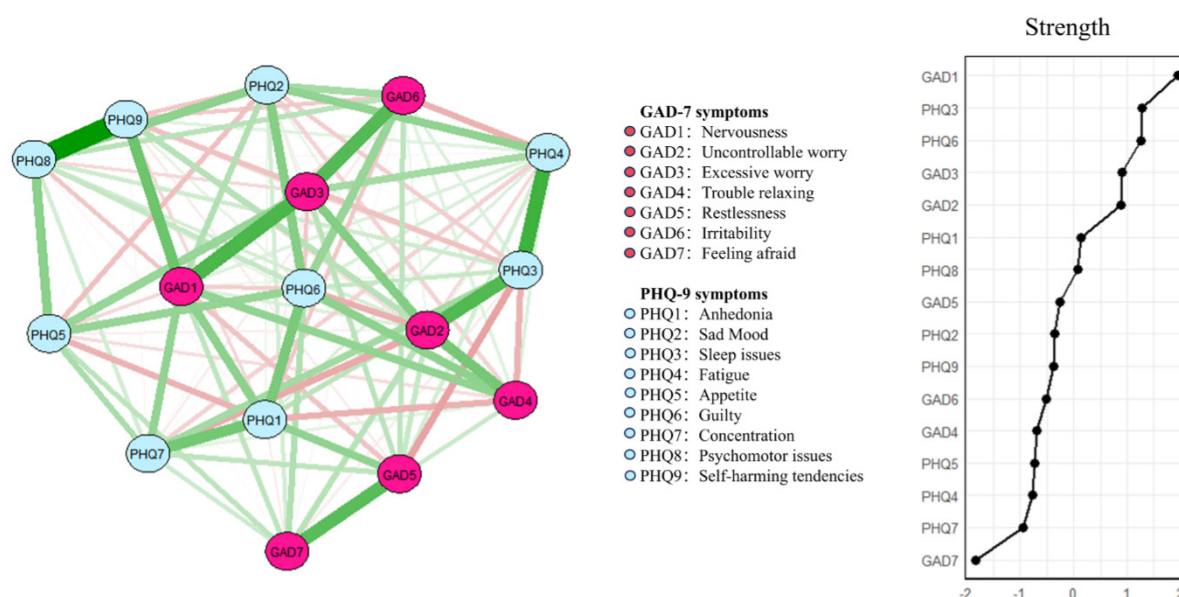


Figure 1. Network structure of anxiety and depressive symptoms in Chinese international student-athletes.

(PHQ3-PHQ4), and Nervousness-Excessive worry (GAD1-GAD3), highlighting the most prominent pairings. This visualization emphasizes the interconnectedness of symptoms and identifies potential targets for intervention.

Figure 2 highlights bridge symptoms linking anxiety and depression among Chinese international student-athletes. Nervousness (GAD1) shows the

highest bridge strength, followed by Guilty feelings (PHQ6) and Sleep issues (PHQ3). This visualization emphasizes the pathways connecting anxiety and depression, offering insights for targeted interventions.

Table 2 presents descriptive statistics for the PHQ-9 and GAD-7 items, including network metrics such as strength, predictability, and expected

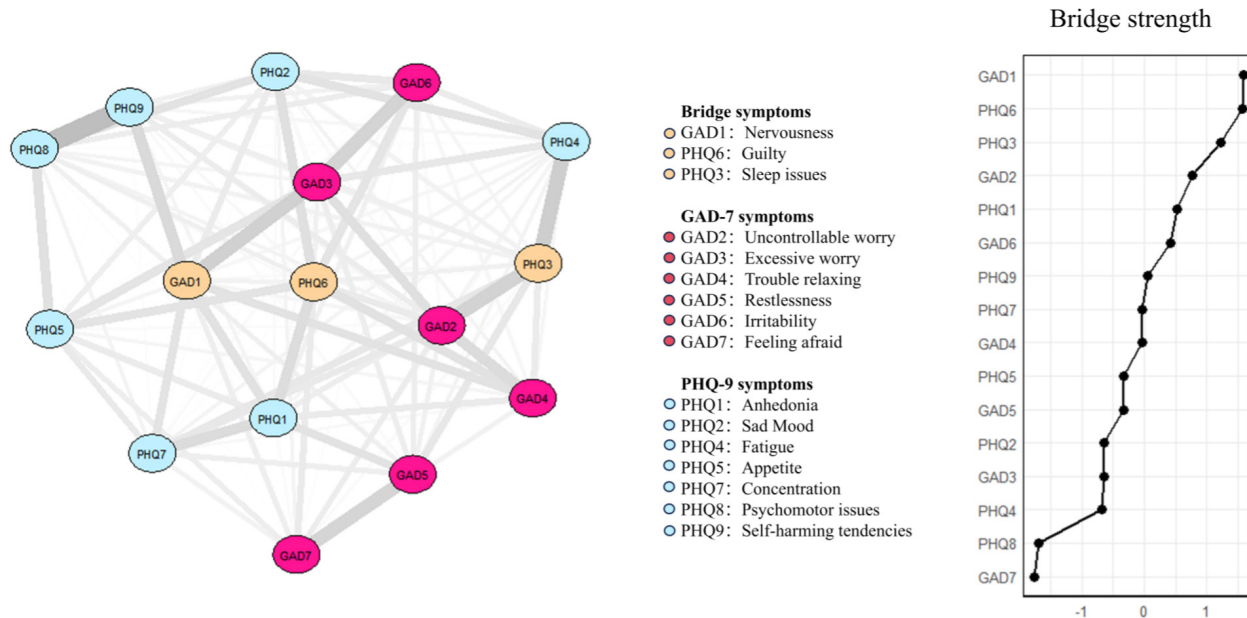


Figure 2. Network structure of anxiety and depressive symptoms present bridge symptoms in Chinese international student-athletes. Edge colors are omitted to avoid color mixing

Table 2. Descriptive statistics of the PHQ-9 and GAD-7 items

Item	Content	Item mean (SD)	Strength*	Predictability	Expected Influence*
GAD1	Nervousness	1.33 (0.79)	2.281	0.666	1.264
GAD2	Uncontrollable worry	1.05 (0.81)	2.048	0.610	1.137
GAD3	Excessive worry	1.33 (0.78)	2.052	0.567	1.099
GAD4	Trouble relaxing	1.19 (0.80)	1.704	0.455	0.566
GAD5	Restlessness	1.04 (0.67)	1.800	0.420	0.680
GAD6	Irritability	0.89 (0.67)	1.744	0.454	0.713
GAD7	Feeling afraid	1.02 (0.720)	1.452	0.615	1.140
PHQ1	Anhedonia	1.11 (0.81)	1.884	0.505	0.722
PHQ2	Sad Mood	0.80 (0.71)	1.777	0.577	0.822
PHQ3	Sleep issues	1.24 (0.80)	2.135	0.468	0.743
PHQ4	Fatigue	1.23 (0.75)	1.685	0.517	0.940
PHQ5	Appetite	0.81 (0.81)	1.695	0.359	0.497
PHQ6	Guilty	0.79 (0.74)	2.132	0.631	1.330
PHQ7	Concentration	1.11 (0.69)	1.645	0.512	0.911
PHQ8	Psychomotor issues	0.88 (0.81)	1.872	0.672	1.390
PHQ9	Self-harming tendencies	0.19 (0.57)	1.772	0.501	0.480

Note. GAD-7 7-item Generalized Anxiety Disorder Scale, PHQ-9 the 9-item Patient Health Questionnaire, SD standard deviation. *The original values of strength were raw data from the network

influence. Nervousness (GAD1), Sleep issues (PHQ3), and Guilty feelings (PHQ6) demonstrated the highest node strength, while Psychomotor issues (PHQ8) emerged as the most influential symptom. These findings highlight the significant role of key symptoms in explaining variance within the network.

The distribution of GAD-7 scores, presented in Figure 3, indicates a wide range of anxiety severity levels. The results suggest that a significant portion of the sample experiences mild to moderate levels

of anxiety, with fewer individuals showing severe symptoms. Similarly, the PHQ-9 scores, also visualized in Figure 3, exhibit a varied distribution of depression severity levels. While many participants report mild symptoms of depression, severe depressive symptoms are less common.

In Figure 4, the stability of the anxiety-depression network was evaluated using case-dropping bootstrapping with the bootnet package in R. The correlation stability coefficient (CS-C) for strength was 0.517, while the CS-C for bridge strength

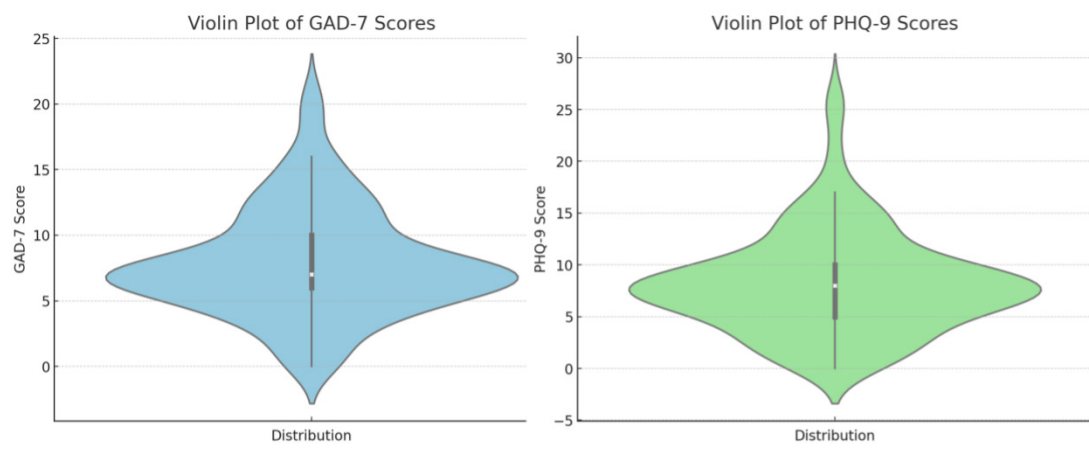


Figure 3. Violin plot visualization of GAD-7 and PHQ-9 scores

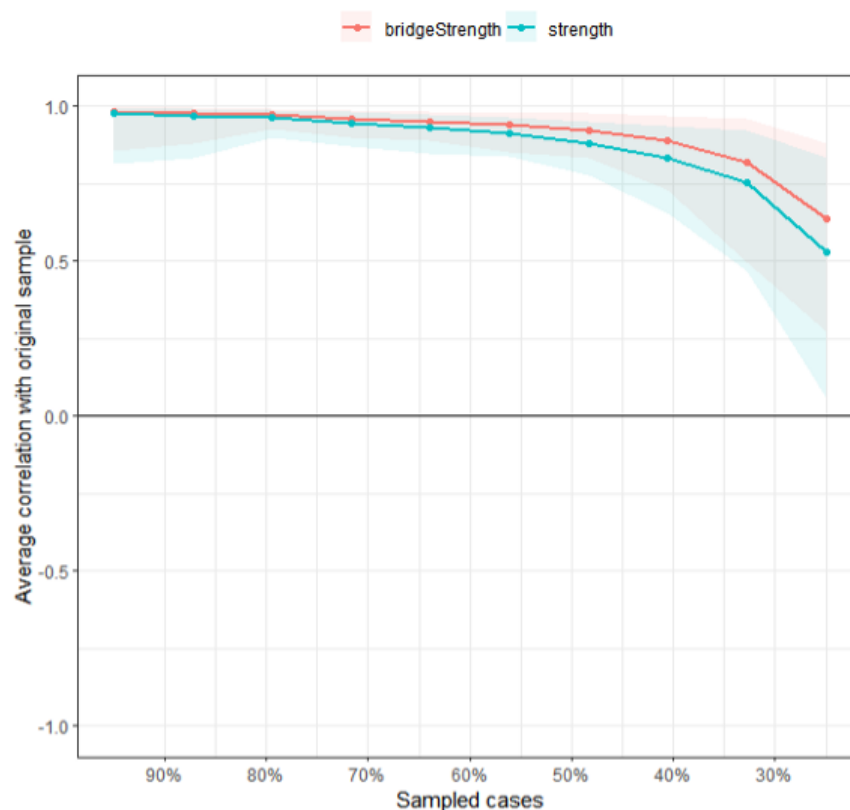


Figure 4. The stability test of strength and bridge strength by using case-dropping bootstrap. The x-axis represents the percentage of the original sample included, and the y-axis shows the average correlation between the centrality indices of the original network and those from re-estimated networks after excluding cases.

was 0.594. Both values exceed the recommended threshold of 0.5, indicating that the network metrics are stable under case-dropping conditions. The visual representation shows a gradual decline in the average correlation with the original sample as more cases are removed, with bridge strength demonstrating slightly higher stability compared to strength. Additionally, to assess the difference between two edges or two node strengths, a nonparametric bootstrap test based on a 95% confidence interval (CI) was performed. Figures 5 and 6 in the Supplementary figures show the results of bootstrapped confidence intervals in edges and bootstrap differences in node strengths.

Using the Spin Glass algorithm, three distinct communities were identified within the anxiety-depression network, as shown in Figure 7. The first community consists of Nervousness (GAD1), Excessive worry (GAD3), Irritability (GAD6), Sad Mood (PHQ2), Psychomotor issues (PHQ8), and Self-harming tendencies (PHQ9). The second community includes Uncontrollable worry (GAD2), Trouble relaxing (GAD4), Sleep issues (PHQ3), and Fatigue (PHQ4). The third community comprises Restlessness (GAD5), Feeling afraid (GAD7), Anhedonia (PHQ1), Appetite (PHQ5), Guilty feelings (PHQ6), and Concentration issues (PHQ7).

Discussion

This study aimed to systematically reveal the structure and associations of the depression and anxiety network among student-athletes during their study abroad. In the overall depression and anxiety network, the two strongest connections are located within depression symptoms, consistent with previous network findings [42, 43]. Strong associations typically occur within the same symptom clusters, partially aligning with earlier research [29, 44]. However, when the scope of strong associations is expanded, cross-symptom links such as Uncontrollable worry (GAD2)-Sleep issues (PHQ3) and Excessive worry (GAD3)-Guilty feelings (PHQ6) emerge. The close relationship between anxiety and depression has been corroborated by previous research, which examined the overlap between ruminative thought patterns in anxiety and self-critical thought patterns in depression [45].

The differences in our research may be due to variations in research samples. For example, this study focuses on Chinese international student-athletes, whereas previous studies have examined other groups, such as nursing students or remote students [32, 42]. Additionally, the participants in this study have dual identities as international students and student-athletes. Previous research has demonstrated a correlation between anxiety and depression in international student populations [46]. Similarly, studies have confirmed the presence

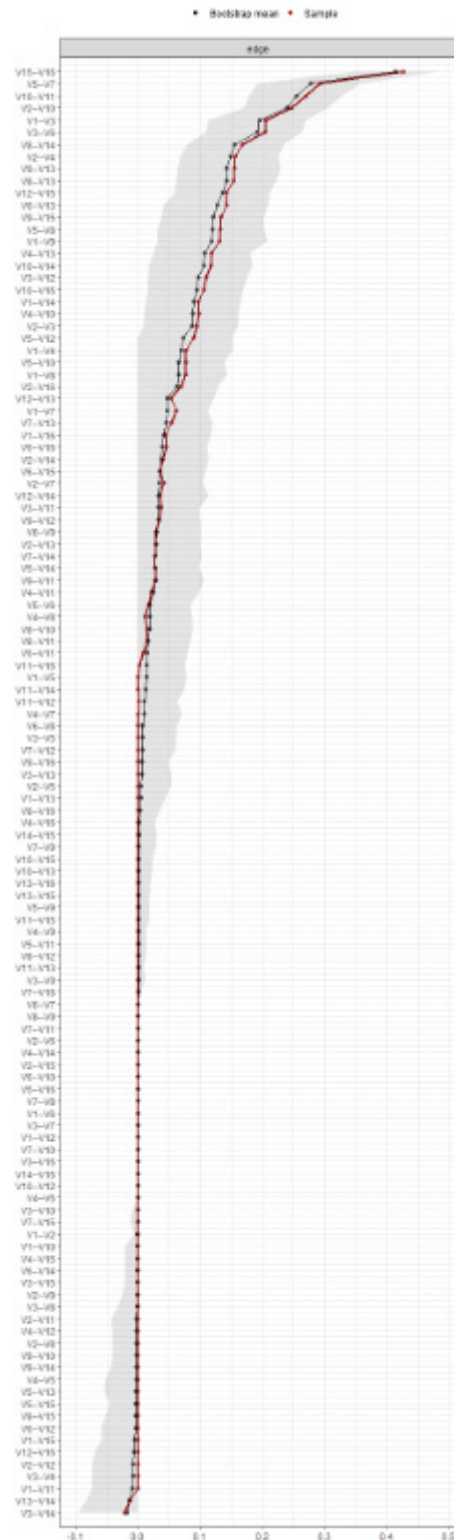


Figure 5. Bootstrapped confidence intervals of all edges. The black dots indicate the values of each edge weight, ordered from the highest to the lowest value. The grey area represents the 95% Confidence Intervals of edge weights, estimated with the non-parametric bootstrap procedure. Wide intervals indicate lower stability and narrow intervals indicate higher stability. V1 to V7 represent GAD1 to GAD7. V8-V16 represent PHQ1-PHQ9.

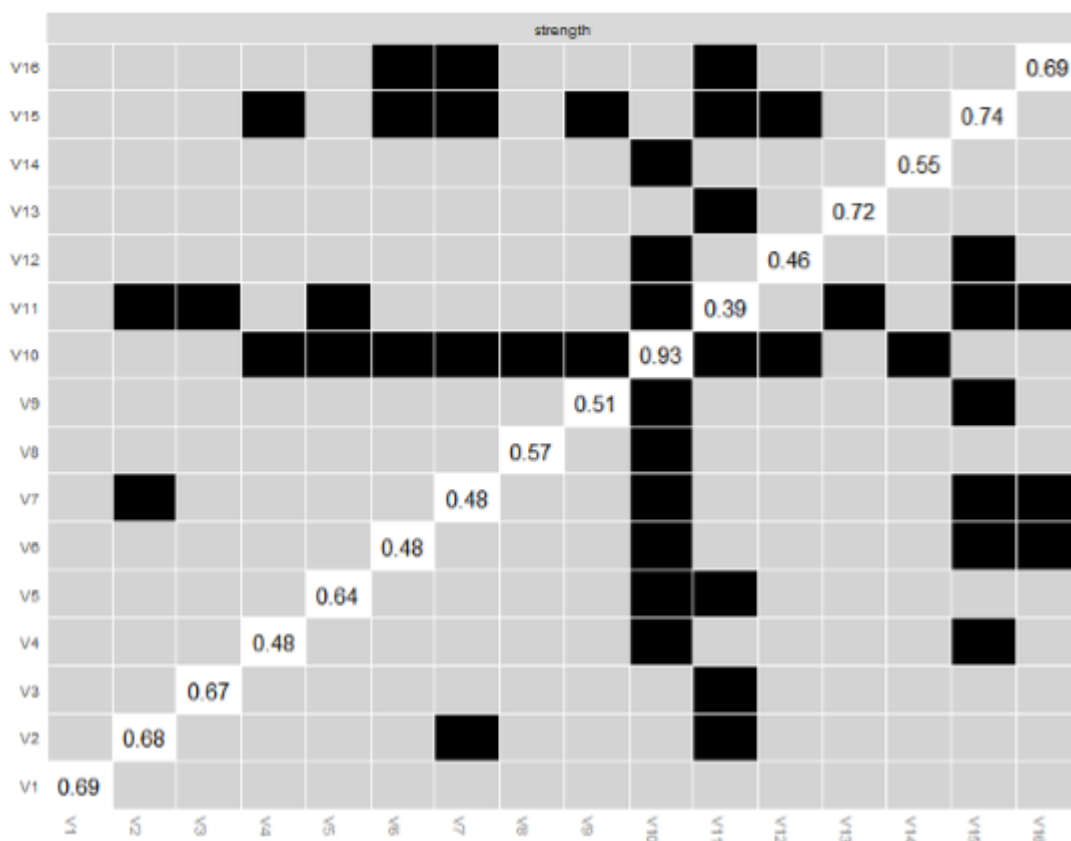


Figure 6. The stability test for ‘node strength’ based on Bootstrap. The grey boxes reflect no significant differences and black boxes reflect significant differences. The number in the white boxes (i.e., the diagonal line) denotes the value of node strength of a specific node. V1 to V7 represent GAD1 to GAD7. V8-V16 represent PHQ1-PHQ9.

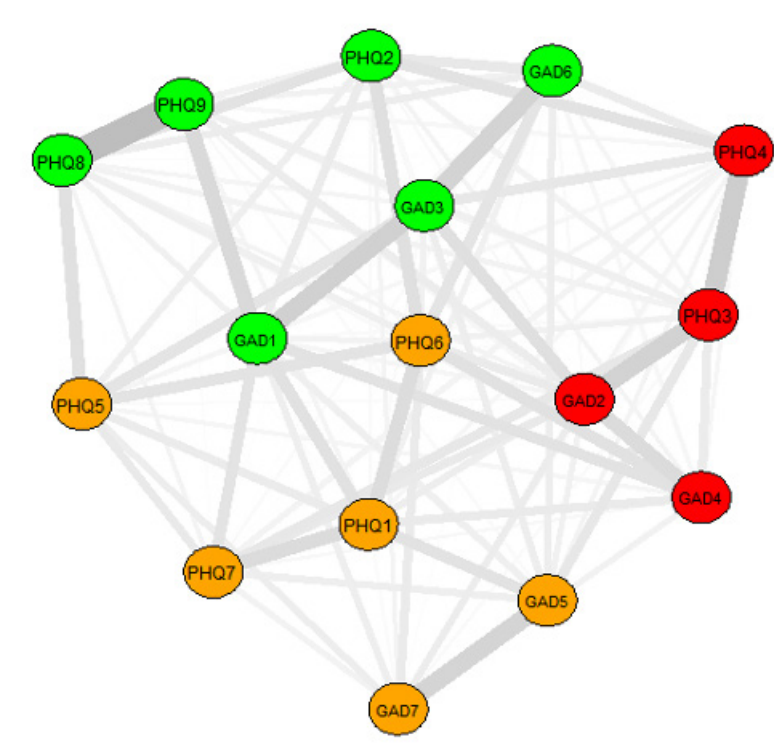


Figure 7. Community Detection Visualization. Different colors represent different communities. Edge colors are omitted to avoid color mixing.

of anxiety and depression correlations within the student-athlete group [17, 47]. Student-athletes are particularly vulnerable to psychological distress due to challenges in cultural adaptation and academic performance [21]. As they navigate the transition from athlete to student, they inevitably face stressors that can lead to anxiety and depression. While the experiences of athletes often equip them with strong resilience in the face of setbacks [48], it is equally important not to overlook the anxiety that arises when adapting to a new identity. Therefore, understanding the unique psychological health needs of this group and the distinct manifestations of anxiety and depression is critical for developing effective mental health interventions for international student and student-athlete populations.

The node strength index is crucial for identifying prominent symptoms within anxiety and depression networks and potential intervention targets. In the overall network, nervousness (GAD1) exhibits the highest strength, highlighting its core position and critical role in the depression-anxiety network, consistent with previous findings in college students [29]. Additionally, the top five nodes in this study had significantly higher strength than other symptoms, suggesting their importance in activating and maintaining the network. Specifically, GAD2 and GAD3 are associated with excessive worry, while PHQ3 and PHQ6 relate to sleep issues and feelings of guilt.

In the international student population, excessive worry is often driven by factors such as cultural adaptation, language barriers, and feelings of isolation, aligning with this finding [11, 13, 46, 49]. Feelings of guilt have also been identified as a common emotional issue in this group [50]. Sleep problems are prevalent in both international students and student-athletes, further underscoring their importance in interventions [51, 52].

Node strength typically focuses on direct effects, making it suitable for short-term interventions. In contrast, expected influence emphasizes indirect effects, which are more relevant for long-term and systematic approaches [53]. The central position of psychomotor symptoms (PHQ8) in expected influence highlights its significance in predicting depression severity. Psychomotor symptoms are often indicative of depression or its severe subtypes, requiring tailored treatment approaches [54]. Furthermore, these symptoms have been linked to 'death thinking' in previous studies [42], warranting additional focus among student-athletes during their study abroad.

The predictability analysis revealed that the surrounding nodes of each node explained, on average, 53% of its variance. This suggests that approximately half of a symptom's variability in the anxiety-depression network can be attributed to its

direct neighbours. This finding indicates a moderate level of interconnectedness within the network, balancing core symptoms (e.g., psychomotor issues, nervousness) with more peripheral symptoms (e.g., fatigue, irritability, appetite).

For symptoms with higher predictability, such as psychomotor issues, their variability is primarily determined by neighbouring nodes, reflecting strong interdependence within the network and identifying them as key targets for intervention. In contrast, symptoms with lower predictability, such as fatigue and appetite, are more likely influenced by external factors [55], suggesting weaker dependencies on the internal anxiety-depression network. While some symptoms may "co-occur" with others [56], their variance often requires interpretation within the context of external influences.

These findings align with research on the interdependence between anxiety and depression [18, 21]. From a psychological network perspective, interventions targeting highly predictable symptoms may partially alleviate related symptoms in their "neighbourhood" [57]. Conversely, symptoms with low predictability may require more comprehensive strategies, such as sports participation, healthy lifestyle promotion, and social environmental support [58].

The most central bridging symptom is nervousness (GAD1). As a hallmark of anxiety symptoms, nervousness may exacerbate psychological stress and contribute to the comorbidity of anxiety disorders and depression [59]. Nervousness not only occupies a central position within the anxiety cluster but also serves as a key bridge between anxiety and depressive symptoms. For international student-athletes, nervousness may be amplified by the unique pressures of balancing academic and athletic performance [24, 25].

In addition to nervousness, guilt (PHQ6) and sleep problems (PHQ3) emerge as significant symptoms, both originating from the depressive cluster. Sleep problems have been shown to severely disrupt student-athletes' daily training and competitive performance [60]. This evidence underscores the need for targeted and purposeful interventions tailored to the specific challenges faced by student-athletes during their study abroad experience.

From the macroscopic perspective of community detection, the interrelation and clustering of anxiety and depressive symptoms into distinct communities among overseas student-athletes reflect a fundamental characteristic of psychology and psychopathology [57, 61]. This suggests that anxiety and depression may not exist as entirely independent entities but rather share complex connections and mechanisms of influence [57]. Such an approach has been explored in studies related to mental disorder networks [61].

Although the results of the anxiety and depression

network community may not directly contribute to clinical diagnosis, they offer a new perspective on the traditional diagnostic classification system for depression.

This research represents the first exploration of the anxiety and depression symptom network among student-athletes during study abroad, providing valuable insights into the mental health status of international student-athletes and its impact on their academic and social lives. However, several limitations should be noted.

First, due to the relatively small size of this group, the sample size was not as large as in previous studies. As student-athletes constitute a minority population, expanding the sample to include participants from different countries would help validate the findings in future research. Second, the study used cross-sectional data collected through snowball sampling and network recruitment, which limits the ability to identify causal relationships and affects the representativeness of the sample [29]. Third, the use of self-reported measures, specifically the GAD-7 and PHQ-9, to assess anxiety and depression symptoms has inherent limitations and cannot substitute for a formal clinical diagnosis. Lastly, as highlighted in the predictability analysis, this study was unable to account for unexplained variability related to external factors. Future research should include longitudinal data and more detailed demographic information to supplement and validate these findings.

Conclusions

In this study, anxiety and depression were explored by constructing a symptom network for Chinese student-athletes during their study abroad. The results identified core symptoms (e.g., anxiety, sleep issues, and guilt) and a key bridging symptom (nervousness). These findings suggest that future interventions should focus on targeting specific symptoms to improve psychological well-being. Additionally, this study provides valuable insights into the mental health and network characteristics of student-athletes studying abroad, offering a reference for research in higher education. It emphasizes the importance of addressing the unique characteristics of different student populations.

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Conflict of interests

The author declare that there is no conflict of interests.

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