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# The symptom network of internet gaming addiction, depression, and anxiety among children and adolescents

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**Internet gaming addiction (IGA), depression, and anxiety are significant issues among children and adolescents, with substantial social implications. Understanding the specific characteristics of this relationship is crucial for developing effective prevention and intervention strategies. The present study employed network analysis to explore the symptom network of IGA, depression, and anxiety among 1,548 Chinese children and adolescents. The results showed that the core symptoms of IGA among children and adolescents were "tolerance", "withdrawal", and "conflict". There was no significant gender difference in the structure, global strength, and core symptoms of IGA. Although there were no significant differences in the structure of the symptom network of IGA among children and adolescents of different ages, there were significant differences in global strength and some core symptoms ("conflict"). The core symptoms of the comorbidity of IGA, depression, and anxiety in children and adolescents included "feeling downhearted and blue", "breathing difficulty", "difficult to work up the initiative to do things", and "withdrawal". The comorbidity network did not show significant gender and age differences in network structure, but there were significant gender differences in global strength. Furthermore, there were significant gender and age differences in some core symptoms. The social impact of these findings is profound, highlighting the need for targeted interventions in schools and communities to address IGA and its comorbidities. Our results also suggest that interventions should be tailored to consider gender and age differences to maximize effectiveness.**

**Keywords** Network of symptoms, Internet gaming addiction, Depression, Anxiety, Children and adolescents

The global popularization and development of the Internet have progressively transformed internet games into a leisure activity[1]. However, many children and adolescents are over-addicted to internet games because they are still in the minor stage, and their cognitive ability and self-control ability are still developing[2–4]. These individuals become preoccupied with gaming, fabricate their gaming uses, disengage from social connections, family, and friends in order to play, and resort to gaming as a method of psychological escape[5]. Internet gaming addiction has become a serious global public health problem[6–8], affecting the healthy growth of children and adolescents[9,10].

The term "Internet gaming addiction" is defined as a behavioral addiction[11–13] that manifests itself in persistent and repetitive use of the Internet for gaming purposes, leading to serious impairment or distress in one's life[14]. Some other labels such as "online game addiction", "internet gaming disorder", "excessive gaming", "pathological video-Game use", and "problematic online gaming" have been used in the literature to describe similar concepts relating to internet gaming addiction. According to the World Health Organization's International Classification of Diseases (ICD-11), internet gaming disorder is considered a behavioral addiction, of which internet gaming addiction is one of the subtypes[15].

According to the Syndrome Model of Addiction, both substance addiction and behavioral addiction can be considered as a syndrome with a common etiology[16]. Kaptsis et al. (2016)[17] argued that it may be most appropriate to conceptualize the problem of internet gaming addiction as sharing the same characteristics. Some researchers have argued that internet gaming addiction, like internet addiction, has six important symptoms: "salience", "mood alteration", "tolerance", "withdrawal", "relapse", and "conflict"[18,19]. Przybylski et al. (2017)[20] provided a list of symptoms that can be used to diagnose internet gaming disorder, completed by nearly 19,000 participants from the United States, United Kingdom, Canada, and Germany. This list shows that internet gaming disorder

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includes nine symptoms: "preoccupation" (spending too much time thinking about the game), "abandonment of other activities" (reducing or losing interest in other activities), "escape mood" (playing to escape unpleasant feelings), "tolerance" (increasing time spent on the game to keep arousal high), "withdrawal" (feeling moody or anxious when I can not play), "inability to reduce playing" (feeling that I should play less, but I can't), "continue despite problems" (continuing to play even when it causes problems), "deceive" (keeping others from knowing how much I play), and "risk" (risking friends or opportunities because of the game). These symptoms form the symptom network of internet gaming addiction. Furthermore, the characteristics of the association between these symptoms must be further elucidated. Therefore, the present study explores the symptom network of internet gaming addiction in children and adolescents.

Are there gender and age differences in internet gaming addiction? Men are more likely to be addicted to internet games than women[21]. Recent meta-analyses have also shown that men have a higher risk of developing internet gaming addiction[22,23]. Even some studies have suggested that internet gaming disorder is an urgent health concern for men[1]. Gaming cues may also impair the inhibitory control function (executive control) of game-induced cravings in male internet gaming disorder participants to a greater extent than in females[24]. Furthermore, minors are particularly vulnerable to problematic internet game use because of underdeveloped age-related cognitive control[25]. Adolescents are particularly vulnerable to developing mental health risks and addictive behaviors[26]. Xin et al. (2018)[27] reported that older students exhibit higher rates of addiction. Accordingly, the present study speculates that adolescents are more likely to exhibit internet gaming addiction than school-aged children. Thus, this study examines not only gender differences in the symptom network of internet gaming addiction but also age differences.

Internet gaming addiction follows a continuum, with antecedents in etiology and risk factors, through to the development of a "full-blown" addiction, followed by ramifications in terms of negative consequences[12]. According to the Compensatory Internet Use Model (CIUT), addiction is rooted in an individual's response to negative life situations[28]. The Interaction of Person-Affect-Cognition-Execution (I-PACE) Model also suggests that negative emotions influence addiction[29]. When people may feel lonely, bored, or restless in real life, they may find solace and fulfillment in gaming. Escapism, which involves addicted individuals engaging in addictive behaviors as a coping mechanism to confront daily challenges, is a component of mood modification in which they subjectively alter their mood[18]. Escapism emphasizes leaving reality, whereas avoidance strategies underline the ability of games to assist individuals in coping with real problems (e.g., anxiety) by facilitating the regulation of negative emotions and unwanted impulses[30]. Conversely, over-reliance on games to regulate emotions can lead to social isolation and emotional dependency, triggering depression[31,32] and anxiety[33,34].

Studies have revealed a strong relationship between depression and anxiety[35,36], and the comorbidity of depression and anxiety has received much attention[37–39]. Gender differences exist in depression and anxiety[40,41]. McElroy et al. (2018)[42] conducted a longitudinal measure of developmental changes in depression and anxiety in children aged 5–14 years. They found that symptoms form a highly interconnected network, that there is a strong correlation between depression and anxiety, and that as children age, the overall network connections between depression and anxiety become stronger. Therefore, given the strong associations between internet gaming addiction, depression, and anxiety, it is necessary to explore the comorbid network characteristics of these three factors, in addition to the differences based on gender and age.

Nowadays, the usage of psychological networks that conceptualize behavior as a complex interplay of psychological and other components has gained increasing popularity in various research fields[43]. The overall global structural organization, also known as topology, of the phenomenon and the roles played by specific variables in the network can be analyzed through the use of network analysis, which surpasses the capabilities of other statistical approaches[44]. The method of network analysis has been utilized to examine symptom networks[45]. A recent study applied this approach solely to explore the symptom network of internet gaming addiction in children and adolescents with non-suicidal self-injury[7]. Another network analysis showed that the bridge symptoms in the combined network model of internet gaming addiction and depression were "Gaming for escape or mood relief" from the IGD cluster and "No initiative" from the depression cluster[46]. Results from a cross - sectional study involving 341 young people in China who were directly exposed to typhoons indicated that within the Internet Gaming Disorder network, "preoccupation", "gaming despite harms", and "loss of control" occupied the top positions in terms of centrality[47]. However, there still exists a deficiency in the understanding of the symptom network of internet gaming addiction among children and adolescents and of its comorbidity structure with depression and anxiety. Consequently, the current study employs network analysis to conduct a comprehensive investigation into the symptom network of internet gaming addiction among children and adolescents, as well as its comorbidity network associated with depression and anxiety. The research findings will provide valuable insights for the prevention and intervention of the coexistence of depression, anxiety, and internet gaming addiction among children and adolescents.

## Methods

### Participants

The study used convenience sampling to select 1957 students from grades 4–9 in Chinese primary and secondary schools. After excluding the number of students who never played internet games ($n=334$) and those who did not answer the question ($n=74$), the remaining number of students (who "play internet games") was 1548. Table 1 shows the basic characteristics of the participants, whose ages ranged from 9 to 16.5 years, with a mean age of 12.39 ($SD=1.69$).

| Variable | Category | *n* | Proportion (%) |
|---|---|---|---|
| 1. Gender | (1) Male | 882 | 56.98 |
| | (2) Female | 666 | 43.02 |
| 2. Grade | (1) Grade 4 | 189 | 12.21 |
| | (2) Grade 5 | 248 | 16.02 |
| | (3) Grade 6 | 225 | 14.53 |
| | (4) Grade7 | 269 | 17.38 |
| | (5) Grade 8 | 321 | 20.74 |
| | (6) Grade 9 | 296 | 19.12 |
| 3. School location | (1) City | 620 | 40.05 |
| | (2) Countryside | 928 | 59.95 |
| 4. Only children family | (1) Yes | 311 | 20.09 |
| | (2) No | 1221 | 78.88 |
| | (3) Miss | 16 | 1.03 |

**Table 1**. Basic characteristics of the participants.

## Measures

*Internet gaming addiction*

The study utilized the 11-item Chinese version of the Internet Gaming Disorder questionnaire[8]. This instrument has been employed in numerous studies examining internet gaming addiction within a Chinese population[48,49]. To measure the tendency towards internet gaming addiction, we used a three-level Likert scale, with a score of 0 assigned to "never," 0.5 assigned to "sometimes," and 1 assigned to "often." A higher score on the questionnaire indicates a greater tendency towards internet gaming addiction. The reliability of the questionnaire was assessed using the Cronbach α coefficient, which yielded a value of 0.81 in this study.

*Depression and anxiety*

Depression and anxiety were evaluated using the Depression Anxiety Stress Scale (DASS-21) developed by Lovibond PF and Lovibond SH (1995)[50]. The present study used the Chinese version of the DASS-21 [51]. Each subscale consists of seven items, with a three-point Likert scale used. Higher scores indicate a greater tendency towards depression or anxiety. The Cronbach alpha coefficients for the depression and anxiety subscales in this study were 0.85 and 0.82, respectively.

*Procedure*

The participants for this study comprised students (grades 4–9) from six primary and secondary schools in Hunan and Jiangxi provinces in China. Prior to data collection, permission was obtained from the school principals, students, and their parents. The researcher distributed and collected the questionnaires during class time, ensuring an even distribution and collection process.

## Data analysis

Following data collection, the JASP 0.17.2.1 software was used to conduct frequency analysis, descriptive statistics, correlation analysis, and network analysis. Core symptoms were measured using centrality indicators (Betweenness (Bet), Closeness (Clo), Strength (Str)), with higher centrality indicators indicating more core symptoms. Consistent with previous research, the top four symptoms in the overall centrality ranking were identified as the core symptoms[52]. The R package "NetworkComparisonTest" was used to perform permutation tests to investigate the significance of network invariance, global strength (GS), and centrality invariance across gender and stage. The study completed 5000 permutations to maintain the rigor of the analysis.

## Ethics approval and consent to participate

was granted by the Academic Committee of School of Preschool Education, Changsha Normal University (20221101). Written informed consent was obtained from all participants. All participants were informed of voluntarily participating and could withdraw from the study at any time. Informed consent from parents was obtained from the minor participants involved in the study. All methods were performed following the Declaration of Helsinki.

# Results

## Common method deviation test

In this study, the common method bias was assessed using Harman's one-way test. The results revealed that the total variance explained by the first common factor was 31.54%, which falls below the critical value of 40%. This finding suggests that there is no significant common method bias present in this study.

## Correlation analysis of key variables

Pearson's product-difference correlation analysis revealed a significant positive correlation between gender (0 = female, 1 = male) and internet gaming addiction (Table 2). This indicates that males were more likely to

| | M ± SD | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| 1. Gender | — | 1 | | | | |
| 2. Stage | — | −0.03 | 1 | | | |
| 3. IGD | 2.20 ± 1.82 | 0.17*** | 0.18*** | 1 | | |
| 4. Depression | 3.58 ± 4.12 | 0.01 | 0.13*** | 0.47*** | 1 | |
| 5. Anxiety | 4.34 ± 4.16 | −0.01 | 0.18*** | 0.43*** | 0.80*** | 1 |

**Table 2**. Correlation matrix of key variables. Note: $^{***}p < 0.001$.

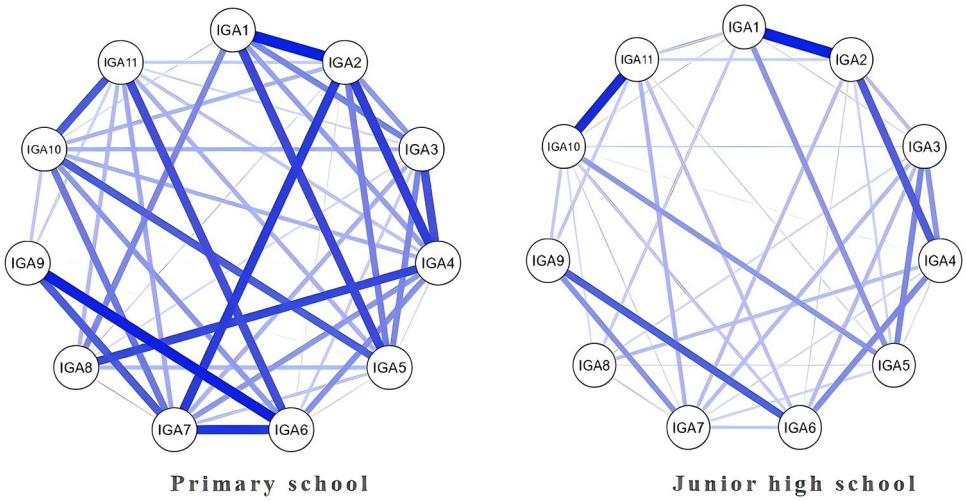


**Fig. 1**. GLASSO network structure on internet gaming addiction.
*Note*: To emphasize the network structure, this study utilized a "spring" distribution in the total network. And a "circle" distribution was utilized to compare the different gender and stage.

exhibit tendencies towards internet gaming addiction compared to females. The correlation between gender, depression, and anxiety was not significant. There was also a significant positive correlation between stage (0 = primary school, 1 = junior high school) and internet gaming addiction, depression, and anxiety. This suggests that as students progress from primary school to junior high school, their scores for internet gaming addiction, depression, and anxiety tend to increase. A significant positive correlation was found between internet gaming addiction and depression and anxiety.

## Network analysis of internet gaming addiction

Figure 1 displays a strong interaction between the symptoms of internet gaming addiction in children and adolescents (overall, across genders and school years). Overall, symptom 2 ("tolerance") was at the center of the network structure. Furthermore, the strength of the connection between symptom 2 ("tolerance") and symptom 1 ("salience") was the strongest.

Comparison of the networks of children and adolescents of different genders (male and female) showed that they did not differ significantly in terms of network structure ($M = 0.117$, $p = 0.828$) and global strength (GS (male) = 4.309, GS (female) = 4.158, $S = 0.151$, $p = 0.388$). And comparing the networks of children and adolescents of different stages (primary school and junior high school) revealed that the two showed significant differences in global strength, although there was no significant difference in network structure ($M = 0.176$, $p = 0.115$). Specifically, GS (primary school) = 3.916, GS (junior high school) = 4.380, $S = 0.463$, $p < 0.05$.

According to the centrality indicators for each symptom (Fig. 2), the core symptoms of internet gaming addiction in children and adolescents included 2 ("tolerance") (Bet = 1.152, Clo = 1.364, Str = 1. 474), 4 ("withdrawal") (Bet = 1.802, Clo = 1.352, Str = 0.530), 6 ("withdrawal") (Bet = 1.802, Clo = 1.352, Str = 0.530), 6 ("conflict") (Bet = 1.152, Clo = 0.820, Str = 0.454), and 7 ("conflict") (Bet = −0.473, Clo = 0.305, Str = 0.616).

As was shown in Fig. 3, the core symptoms of internet gaming addiction in males were 2 (Bet = 1.699, Clo = 1.163, Str = 1.522), 4 (Bet = 1.265, Clo = 1.286, Str = 0.130), 6 (Bet = 0.395, Clo = 0.008, Str = 0.653), and 7 (Bet = 0.395, Clo = 0.941, Str = 0.450). The core symptoms of internet gaming addiction in females were 4 (Bet = 2.111, Clo = 1.745, Str = 1.198), 2 (Bet = 0.603, Clo = 0.872, Str = 1.104), 6 (Bet = 0.905, Clo = 0.819, Str = 0.146), and 7 (Bet = 0.905, Clo = 0.638, Str = 0.868). Comparison of the symptom networks between genders revealed no significant differences ($p > 0.05$) in the centrality indicators of these four core symptoms.

Furthermore, the core symptoms of internet gaming addiction among primary school students were 7 (Bet = 1.818, Clo = 1.391, Str = 1.155), 2 (Bet = 1.230, Clo = 1.395, Str = 1.075), 4 (Bet = 1.230, Clo = 0.973, Str = 1.031), and 6 (Bet = 0.348, Clo = 0.461, Str = 0.407). The core symptoms of internet gaming addiction in

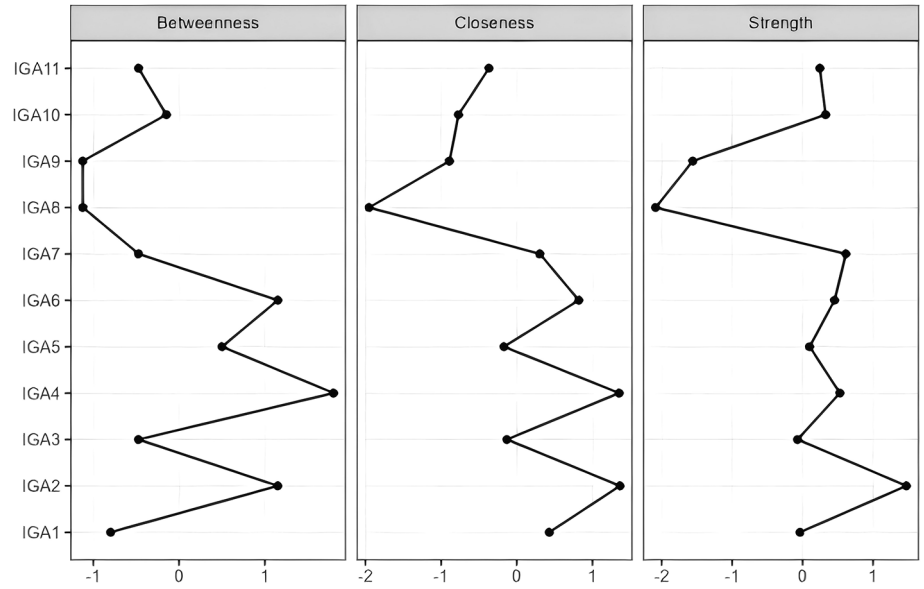


**Fig. 2**. Indicators of the centrality of the networks on internet gaming addiction.

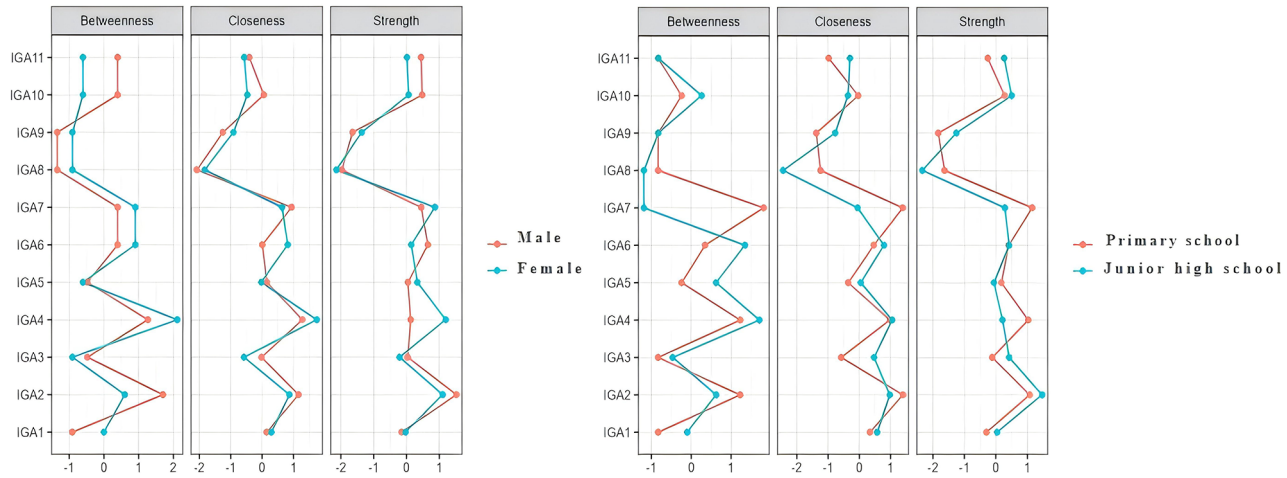


**Fig. 3**. Indicators of the centrality of the networks of different genders and stages.

junior high school students were 7 (Bet = 0.626, Clo = 0.977, Str = 1.473), 2 (Bet = 1.713, Clo = 1.052, Str = 0.214), 4 (Bet = 1.350, Clo = 0.792, Str = 0.425), and 1 (Bet = 0.263, Clo = -0.364, Str = 0.505). Comparison of the symptom networks by stages revealed that the two showed significant differences only in the centrality indicator betweenness for symptom 7, Bet (primary school) > Bet (junior high school), $p < 0.01$, and not in the centrality indicators for the other core symptoms.

## Network analysis of internet gaming addiction and depression and anxiety

Item scores were standardized in this study because of the different scoring methods of the scales (e.g., ZIDA 1). As displayed in Fig. 4, there was a strong interaction between internet gaming addiction and depression and anxiety in children and adolescents (overall, by genders). Overall, depression symptom 2 ("difficult to work up the initiative to do things") and anxiety symptom 4 ("fear of panic and making a fool") were at the center of the network structure. In addition, the strength of the connection between depressive symptom 4 ("feel downhearted and blue") and anxiety symptom 5 ("close to panic") was the strongest, followed by the strength of the connection between internet gaming addiction symptom 1 ("salience") and internet gaming addiction symptom 2 ("tolerance").

Comparing the comorbidity networks of children and adolescents of different genders revealed no significant difference in network structure ($M = 0.118$, $p = 0.984$) but significant differences in global strength. Specifically, global strength was significantly greater in males (GS (male) = 11.165) than in females (GS (female) = 10.576), $S = 0.589$, $p < 0.05$. And comparison of the comorbidity networks of children and adolescents of different stages

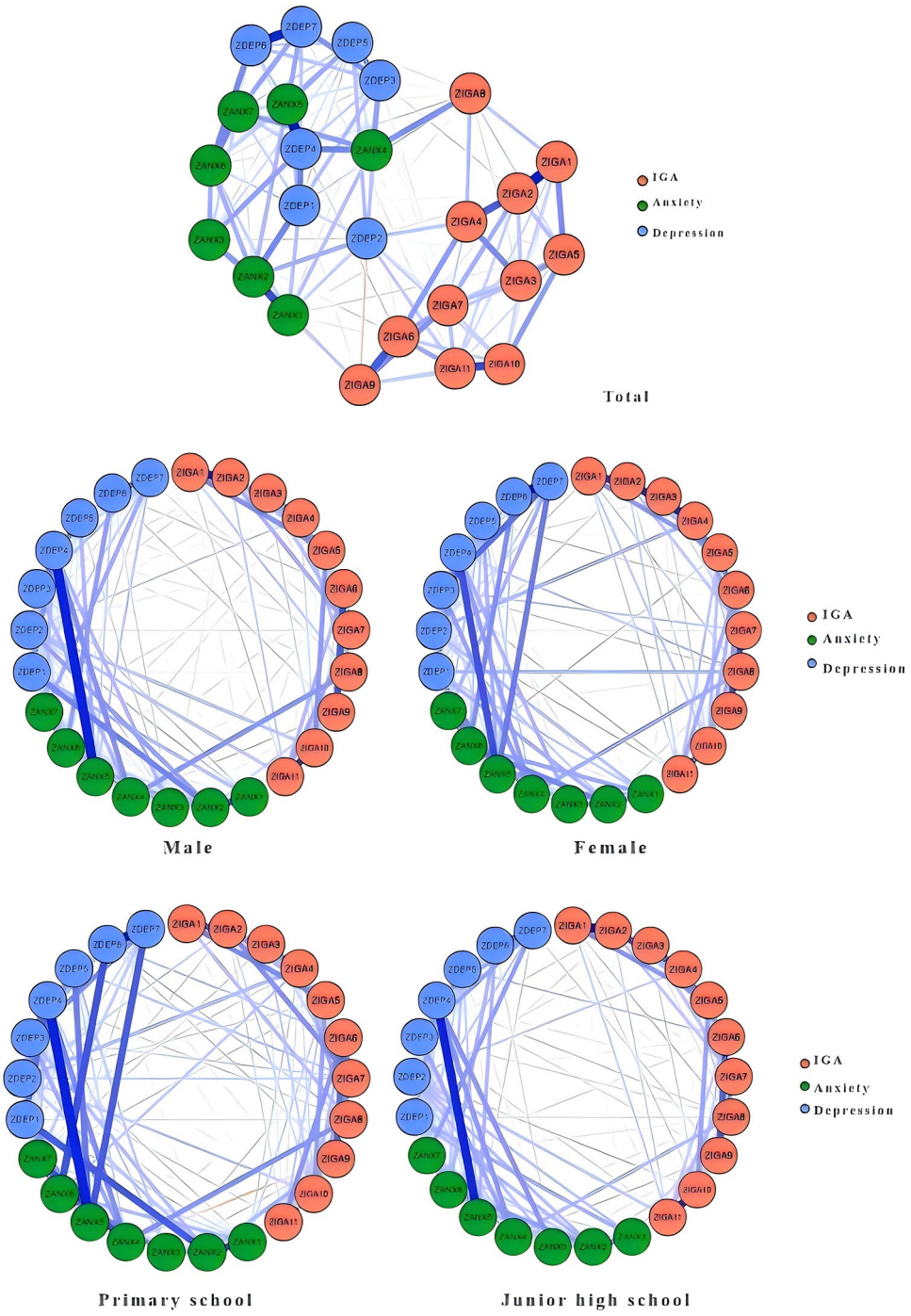


**Fig. 4**. GLASSO network structure on internet gaming addiction and depression, anxiety.
*Note*: To emphasize the network structure, this study utilized a "spring" distribution in the total network. And a "circle" distribution was utilized to compare the different genders and stages.

showed that both were not significant in terms of network structure ($M = 0.165$, $p = 0.364$) and global strength (GS (primary school) = 10.883, GS (junior high school) = 11.322, $S = 0.439$, $p = 0.120$) were not significantly different in either case.

According to the centrality indicators of each symptom (Fig. 5), the core symptoms of the comorbidity network consisting of child and early adolescent internet gaming addiction with depression and anxiety were depression symptom 4 ("downhearted and blue") (Bet = 0.015, Clo = 0.588, Str = 2.342), anxiety symptom 2 ("breathing difficulty") (Bet = 1.743, Clo = 1.783, Str = 0.913), depression symptom 2 ("difficult to work up the initiative to do things") (Bet = 2.175, Clo = 1.602, Str = 0.601), and internet gaming addiction symptom 4 ("withdrawal") (Bet = 1.619, Clo = 0.819, Str = 0.093).

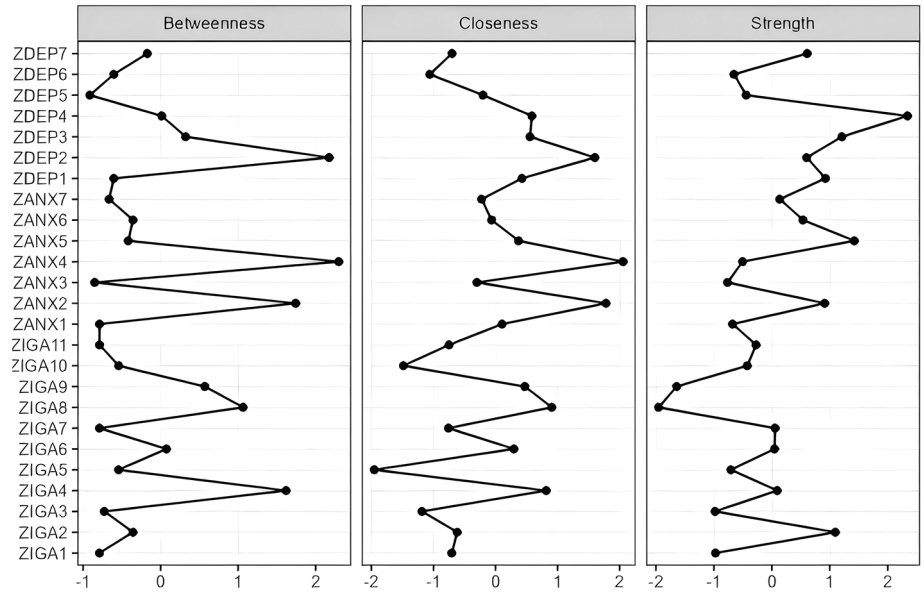


**Fig. 5**. Indicators of the centrality of the networks on three variables.

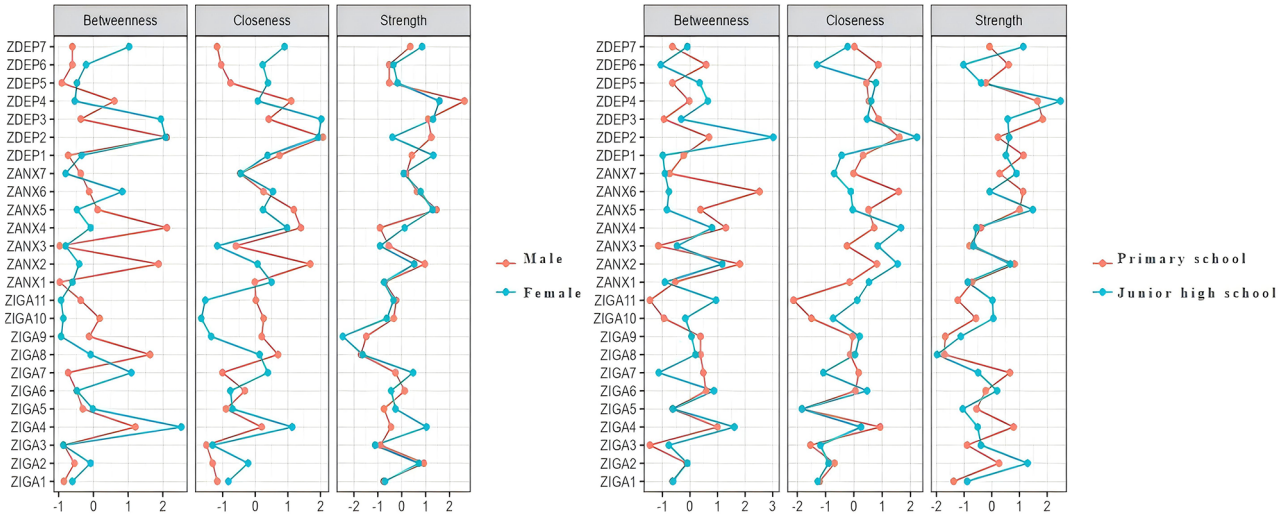


**Fig. 6**. Indicators of the centrality of the networks of different genders and stages.

As was shown in Fig. 6, the core symptoms for males were depression symptom 4 ("downhearted and blue") (Bet = 0.605, Clo = 1.104, Str = 2.626), depression symptom 2 ("difficult to work up the initiative to do things") (Bet = 2.118, Clo = 2.077, Str = 1.244), anxiety symptom 5 ("close to panic") (Bet = 0.121, Clo = 1.184, Str = 1.461), and anxiety symptom 2 ("breathing difficulty") (Bet = 1.876, Clo = 1.688, Str = 0.969). The core symptoms for females, which were different from males, were depression symptom 3 ("nothing to look forward to") (Bet = 1.947, Clo = 2.028, Str = 1.311), internet gaming addiction symptom 4 ("withdrawal") (Bet = 2.535, Clo = 1.138, Str = 1.038), depression symptom 7 ("life was meaningless") (Bet = 1.032, Clo = 0.900, Str = 0.853), anxiety symptom 6 ("be aware of the action of my heart in the absence of physical exertion") (Bet = 0.836, Clo = 0.546, Str = 0.786). Comparing the core symptoms of cyberbullying in children and adolescents of different genders revealed that Str (male) > Str (female) on depression symptom 2, $p < 0.01$. On depression symptom 3, Bet (male) < Bet (female), $p < 0.05$.

The core symptoms for the primary school students were anxiety symptom 6 ("aware of the action of my heart in the absence of physical exertion") (Bet = 2.525, Clo = 1.584, Str = 1.134), depression symptom 4 ("downhearted and blue") (Bet = -0.024, Clo = 0.529, Str = 1.653), anxiety symptom 5 ("close to panic") (Bet = 0.383, Clo = 0.520, Str = 1.006), anxiety symptom 2 ("breathing difficulty") (Bet = 1.811, Clo = 0.812, Str = 0.821). The core symptoms for junior high school students were depression symptom 4 ("downhearted and blue") (Bet = 0.650, Clo = 0.615, Str = 2.488), anxiety symptom 2 ("breathing difficulty") (Bet = 1.170, Clo = 1.549, Str = 0.666),

depression symptom 2 ("difficult to work up the initiative to do things") (Bet = 3.026, Clo = 2.231, Str = 0.627), internet gaming addiction symptom 6 ("conflict") (Bet = 0.873, Clo = 0.471, Str = 0.193). Comparing the core symptoms of the internet in children and adolescents of different ages revealed a significant difference in anxiety symptom 6 (Clo (primary school) > Clo (junior high school), $p < 0.05$; Bet (primary school) > Bet (junior high school), $p < 0.01$), whereas there was no significant difference on other core symptom centrality indicators.

## Discussion

### Internet gaming addiction among children and adolescents

The present study was based on the syndrome model of addiction and used a network analysis approach. Among the six important symptoms of internet gaming addiction, the core symptoms were "tolerance", "withdrawal", and "conflict". Firstly, the symptom of "tolerance" emerged as the most salient node within the symptom network of internet gaming addiction, aligning with findings from previous study that have utilized network analysis in the context of behavioral addictions[46]. In the realm of internet gaming, tolerance manifests as an escalating need to invest more time in gaming activities[53], a pattern observed across various digital addictions. This phenomenon underscores the critical role of tolerance in the progression of behavioral addictions, where individuals are compelled to amplify their engagement to achieve the same level of satisfaction[12]. The second core symptom is "withdrawal". Internet gaming withdrawal is most consistently referred to as "irritability" and "restlessness" following cessation of the activity[16]. The drive to reduce aversive withdrawal states forms the basis of the negative reinforcement model dependency of addiction[54]. The final core symptom is "conflict", and it refers to conflicts between addicted people and those around them (interpersonal conflict) or from within the individual themselves (intrapsychic conflict) that are concerned with the particular activity[18]. Existing studies and analyses have revealed that conflict is a prominent manifestation of the symptoms associated with internet gaming addiction[47], and that being "clearly aware of the dangers of internet games but failing to stop" is one of the core symptoms for identifying this addiction[7]. Many children and adolescents recognize that playing internet games damages important relationships, yet they continue to play.

The present study also found that males scored significantly higher on internet gaming addiction compared with females, consistent with the results of previous studies[21,22]. However, no significant gender differences were observed in the network structure, global strength, and core symptoms of internet gaming addiction. This finding requires further verification in future studies. Although no significant age differences were found in the symptom network structure of internet gaming addiction among children and adolescents, there were significant differences in the global strength and betweenness of some core symptoms, such as "conflict". Moreover, junior high school students, being in the special life stage of adolescence, often exhibit more prominent rebellious psychology, lower self-control, and frequent inner conflict. Adolescents with gaming addiction may identify more with their online selves than their offline selves[55]. Given that the global strength of the symptom network of internet gaming addiction is significantly greater in junior high school students than in primary school students, teachers or counselors may face greater challenges in intervening with internet gaming addiction among junior high school students compared to primary school students.

### The relationship between internet gaming addiction and depression and anxiety

The present study not only found that there was a significant positive correlation between internet gaming addiction and depression and anxiety among children and adolescents but also found that the symptoms at the center of the three comorbidity networks are the depression symptom "difficult to work up the initiative to do things" and the anxiety symptom "fear of panic and making a fool". The symptoms at the center of the network were the depression symptom "difficulty to work up the initiative to do things" and the anxiety symptom "fear of panic and making a fool". Furthermore, the core symptoms of the comorbid network consisting of internet gaming addiction, depression, and anxiety included the depression symptom of being "downhearted and blue", the anxiety symptom of "breathing difficulty", the depression symptom of "difficult to work up the initiative to do things", and the internet gaming addiction symptom of "withdrawal". Internet gaming disorder and depression share common neural substrates[31]. In addition, it has been proposed that the withdrawal symptoms of addiction play a significant role in the network of symptoms of comorbid anxiety[56]. Thus, the findings of the present study may reveal the form of emotions expressed by individuals with internet gaming addiction and may imply the influence of negative emotions on internet gaming addiction, thus validating the I-PACE model.

From the perspective of gender differences in the comorbidity network, although there was no significant difference in the network structure of the comorbidity network, the global strength of the male network was greater than that of the female network. As the degree of network connectivity may be related to treatment response[57], this result may mean that prevention and intervention for internet gaming addiction, depression, and anxiety in men may take a longer time. From the point of view of symptoms, although the most prominent core symptoms of both males and females were depression symptoms, the specific manifestations were different. The most prominent core symptom for males was "downhearted and blue", whereas the most prominent core symptom for women was "nothing to look forward to". Studies have revealed that the sense of hopelessness may lead individuals to become addicted to internet games to escape the challenges of reality[58]. Moreover, maladaptive emotion regulation strategies exacerbate internet gaming addiction[59]. Therefore, the findings of the present study suggest that when addressing the comorbidity of internet gaming addiction, depression, and anxiety in children and adolescents, we should commence with emotion regulation and the provision of hope.

In addition, from the age difference of the comorbidity network, there was no significant age difference in the network structure and global strength of this network. From the point of view of symptoms, the most prominent core symptom of primary school students was the anxiety symptom, "aware of the action of my heart in the absence of physical exertion". The most prominent core symptom for junior high school students was depression symptom "downhearted and blue". In the anxiety symptom "aware of the action of my heart in the absence of

physical exertion", the value of the network centrality index of primary school students was greater than that of junior high school students. Anxiety symptoms in childhood appear to signal a significant risk for other disorders, particularly depression[60]. Therefore, in the process of dealing with comorbidities, we must focus on the anxiety symptoms of primary school students and the depression symptoms of junior high school students.

## Research implications

The present study utilizes network analysis to investigate the symptomatology of internet gaming addiction among children and adolescents. Importantly, it represents a pioneering effort in examining the comorbid symptom network that encompasses internet gaming addiction alongside depression and anxiety within this population. This methodology reinforces both the syndrome model of addiction and the notion of compensatory internet use, indicating that symptoms of addiction are interrelated rather than isolated phenomena, forming part of a broader psychological syndrome. By analyzing symptom networks across various genders and age groups—specifically differentiating between primary school students and junior high school students—the study seeks to identify variations attributable to unique individual characteristics and developmental stages. This comprehensive examination offers an intricate understanding of how symptoms associated with internet gaming addiction manifest and interact with other mental health concerns, as well as how these patterns may evolve with age and gender. Such insights are essential for developing targeted prevention and intervention strategies that take into account the complex interplay of factors affecting children's and adolescents' mental health in the digital era.

Firstly, our study indicates that diverse symptoms ought to be appropriately addressed. For example, children and adolescents experiencing "feeling downhearted and blue" should be guided to recognize and efficiently handle negative emotions. They should be taught to learn how to express their feelings, seek support, and positively resolve problems. This approach is in line with the techniques of cognitive - behavioral therapy (CBT), which has been demonstrated to be efficacious in the treatment of internet gaming addiction[61,62]. In the case of "breathing difficulty", teaching deep - breathing techniques such as abdominal breathing can be implemented. This method constitutes a part of mindfulness - based interventions. For "difficulty to work up the initiative to do things", the establishment of small goals and the creation of a stable schedule can assist in forming a regular routine and activities. This is a common strategy within behavioral activation, which is an integral component of CBT. For "withdrawal", it is advisable to set reasonable limits on gaming time and gradually decrease the amount of time spent on internet gaming. This is a strategy employed in family therapy for managing gaming addiction.

Secondly, an understanding of gender differences is of utmost importance. Males should be motivated to engage in sports and outdoor activities to relieve stress and improve physical health.

Numerous studies have demonstrated that physical activity exerts a positive impact on the mental health of children and adolescents[63,64]. Females, on the other hand, should be directed to develop a positive self - image and self - acceptance. These recommendations stem from the recognition that different genders may respond variably to diverse interventions.

Thirdly, age differences must be recognized, and distinct measures should be provided accordingly. For children, enhancing the parent - child relationship and encouraging group activities can promote the development of good interpersonal relationships. For adolescents, constructing supportive peer networks and maintaining positive attitudes in both interpersonal and virtual interactions are indispensable. Schools are of fundamental and indispensable importance in cultivating an environment that is favorable for the development of positive peer relations[65]. Such an environment holds great value in enhancing the mental health and resilience of each child and adolescent, irrespective of their family support background. Consequently, we should attach significant importance to the role of schools within this context.

## Limitations

The present study has some limitations. First, the data collected in this study came from participants' self-reports, and there may be a social approval effect. Future research could use diverse data collection routes. Second, this study is a cross-sectional design and could not draw causal conclusions. Future studies could examine the relationship between internet gaming addiction and depression and anxiety through longitudinal tracking. Third, the instruments for measuring internet gaming addiction, depression, and anxiety were relatively diverse. Future research should validate the results of this study by using other measurement tools. Fourth, this study covered only primary school students and junior high school students so that future research could include high school students in their study.

# Conclusions

This study presents a thorough analysis of the symptom network associated with internet gaming addiction (IGA), depression, and anxiety among children and adolescents. Our findings indicate that the core symptoms of IGA in this population include "tolerance," "withdrawal," and "conflict." These symptoms are consistent across genders, suggesting a universal pattern in how IGA manifests among young people. However, we found age-related differences in the overall strength of the symptom network, indicating that the severity of IGA may fluctuate with different developmental stages. The co-occurrence of IGA with depression and anxiety is characterized by key symptoms such as "feeling downhearted and blue," "breathing difficulties," "difficulty in mustering the initiative to engage in activities," and "withdrawal." While the structure of this comorbidity does not show significant variation by gender or age, notable differences in global strength exist between genders. This underscores the necessity of considering gender-specific factors when developing and treating these mental health issues. The social implications of our findings are substantial. The uniformity of core IGA symptoms across genders highlights the need for gender-neutral prevention strategies aimed at all children and adolescents. Additionally, the age-related differences in global strength suggest that interventions should be customized to

meet the distinct developmental needs of both younger and older children. In terms of prevention, our results emphasize the critical importance of early identification and support for children exhibiting core symptoms of IGA. Schools and communities should implement programs that promote healthy gaming habits and provide resources for children and adolescents at risk of developing IGA and associated mental health issues. Regarding interventions, our findings indicate that treatments should be tailored to address the specific symptoms and comorbidities present in each individual. This may involve a blend of cognitive-behavioral therapy, family therapy, and social support interventions. For future research, we recommend conducting longitudinal studies to monitor the development of these symptom networks over time and to investigate the long-term effects of IGA and its comorbidities on mental health outcomes. Additionally, research should assess the effectiveness of various prevention and intervention strategies, particularly those aimed at high-risk populations.

## Data availability

Data will be made available from the corresponding author on reasonable request.

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## Author contributions
Yuntian Xie: Conceptualization; Methodology; Writing – original draft; Writing – review & editing; Lu Tang: Writing – original draft. All authors read and approved.

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## Declarations

## Competing interests
The authors declare no competing interests.

## Additional information
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