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Depression in High-Ability vs. Typically Developing Adolescents: A Symptom- and Disorder-Level Analysis

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Abstract
High-ability adolescents are recognized to show high intellectual cognition and creativity. Yet they are not immune to mental health issues. It is believed that these adolescents may also experience a range of mental health problems, including depression. However, depression among high-ability adolescents has received inconsistent research attention. This study addresses a critical gap in understanding depression among high ability and typically developing adolescents from both the disorder level and the symptom level. The sample of this study included 3955 adolescents from Hong Kong, Taiwan, the UK, and the Netherlands, with 1162 high-ability adolescents, 2227 male adolescents, 1985 Western adolescents, aged from 12 to 18 (M_{age}=16.19, SD=1.62). Participants' depressive symptoms were measured. For the disorder level, a two-way ANCOVA was performed to explore the effects of high ability, gender, and culture on the overall depression. For the symptom level, network analysis was conducted to construct depression networks in high-ability and typically developing adolescents. Additionally, network comparison was performed to explore the disparity in depression networks between high-ability and typically developing adolescents. The ANCOVA results showed that high-ability, female, and Western adolescents had higher levels of depression than their counterparts, and the interaction effect of high ability and gender was significant. The network analysis revealed *feeling depressed* and *self-deprecation* were core symptoms for both groups, and *losing interest* was the unique core symptom for the high-ability group while *feeling tired* was the unique core symptom for the typically developing group. The identification of core symptoms specific to high-ability versus typically developing adolescents provides clinically relevant insights for tailored interventions. The cross-cultural design spanning Eastern and Western populations also adds significant value to the international applicability of findings.

Keywords High-ability adolescents · Depression · Network analysis · Network comparison

Introduction

High-ability individuals refer to those who have extraordinary performance, giftedness or potential in cognitive intelligence (e.g., reasoning, spatial abilities) and creativity (e.g., originality, inventiveness) (Al-Rousan et al., 2025; Chan, 2011; Duplenne et al., 2023; Kim et al., 2009). In the literature, the term "high ability" is often used interchangeably with "giftedness", "talent", "genius" (Datu, 2025; Mishra et al., 2024). High-ability adolescents are often identified early for their exceptional academic performance and are widely considered to have great potential for future success (Al-Rousan et al., 2025). Despite extensive research, concerns about the mental health challenges of high-ability adolescents continue to rise (Lee et al., 2020). As one of the most prevalent mental health problems, depression approximately affects 4% of the global population and is a leading cause of adolescents' illness and disability (World Health Organization, 2017, 2024). Although the depressive experiences of typically developing adolescents have been an important scientific inquiry for years, the scholarly landscape on the depressive symptoms of gifted or high-ability learners remains scarce.

Prior evidence has painted a controversial backdrop on the association between high ability and depressive symptoms in adolescents (Duplenne et al., 2023; Martin et al.,

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2009; Mishra et al., 2024). There are two competing views that account for high-ability adolescents' depression. On the one hand, high ability could be a protective factor against adolescents' depression for two reasons: (1) high-ability adolescents might demonstrate better capacity to mobilize resources to mitigate their vulnerability to developmental risks; (2) giftedness and resilience share many common characteristics, such as task commitment, reflectiveness and maturity, and high-ability individuals are often considered to have high resilience which can protect them from mental problems (Bland et al., 1994; Eklund et al., 2015; Mueller, 2009). For example, Mishra et al. (2024) examined the mental health among India gifted students and non-gifted students, and the results showed that the depression score of gifted students was significantly lower than non-gifted students. Similarly, a study conducted in Iran high school students showed that gifted adolescents experienced significantly lower levels of depression than non-gifted adolescents (Mueller, 2009). In the study by Cook et al. (2020), gifted children were also found to have lower emotional symptoms than non-gifted children.

On the other hand, high ability might be a risk factor for adolescents' depression. According to Dąbrowski's theory of positive disintegration (Dąbrowski, 1976; Thomson & Jaque, 2016), high-ability individuals tend to be "neurotically allergic or nervous" and possess increased responses to internal and external stimuli within psychomotor, sensory, intellectual, imaginational and emotional domains (over-excitabilities), which are relatively absent in typically developing individuals. Specifically, high-ability adolescents might show heightened responses to their own high self-standard (namely perfectionism; internal stimuli) and high social expectations from others (external stimuli) (Grugan et al., 2021; Mueller, 2009; Reis & McCoach, 2000). These over-excitabilities relate to symptoms of slight neuroses, such as depression (Karpinski et al., 2018). A study by Karpinski et al. (2018) found that the prevalence of mood disorders in the members of American Mensa (a society open to individuals scoring in the top 2% on approved intelligence tests) was significantly higher than the national average. Similarly, Bénony et al. (2007) investigated depression in French children and reported a significantly higher level of depression in the gifted children group than in the control group. These studies supported the view that high-ability individuals are prone to experience asymmetrical development (Neihart, 1999; Silverman, 1997).

Despite many studies supporting the difference in depression between high-ability and typically developing individuals, some studies yet showed that there might be no significant association between high ability and depression. In a meta-analytic review by Duplenne et al. (2023), gifted individuals had fewer depressive symptoms than non-gifted counterparts, but this difference was not significant. Another meta-analytic review of the epidemiologic literature also found no significant differences in the depressive rate between gifted and typically developing individuals (Martin et al., 2009). As for the adolescent group, similarly, Fouladchang et al. (2010) found no significant effect of gifted and non-gifted group in high school students' depression.

Variability within existing research is seen in the adolescents' depression among demographic variables, including gender and culture. Female adolescents were found to have a higher risk of depression than their male peers (Habibi Asgarabad et al., 2023). Specifically, females were reported twice more likely to be diagnosed with depression and may experience higher depression symptoms than males (Marcus et al., 2008; Salk et al., 2017). Depression regarding cultural differences had mixed results. Some studies found that adolescents in Europe had higher depression symptoms than adolescents in East Asia (Wei et al., 2024), while some studies reported that adolescents in East Asia were at greater risk than European adolescents (Alizadeh et al., 2025; Du et al., 2023). Studies further exploring these demographic differences in high-ability adolescents and typically developing adolescents respectively. For example, Mueller (2009) investigated gender differences in gifted adolescents' depression and non-gifted adolescents' depression respectively, and the results showed that females were significantly more depressed than males among both gifted adolescents and non-gifted adolescents. However, to our best knowledge, only several studies explored the interaction effect of gender and giftedness on depression. Specifically, Mishra et al. (2024) investigated the interaction effect on emerging adults' depression between gender and giftedness, and this interaction effect was found to be negligible. Similarly, the study by Fouladchang et al. (2010) did not identify a significant interaction effect of giftedness and gender on high school students' depression. In addition, depression among high-ability adolescents might also be influenced by culture. On one hand, in the context of Eastern collectivism, high-ability adolescents are strongly guided by social expectations and family honor, which may increase their susceptibility to stress and vulnerability to depression (Chen et al., 2020). On the other hand, compared to Western individualism, Eastern collectivism emphasizes social interactions and provides platforms for social connections (e.g., collective class activities), which can provide high-ability adolescents with more family support and peer support (Li & Hao, 2025; Zhang & Han, 2023). Social support can then buffer individuals' depression by improving emotional and material resources, as well as reducing negative effects of stress (Yin et al., 2017). However, there was limited research to explore the interaction effect of culture and high ability on depression, which needs more exploration.

Furthermore, previous studies mostly compared depression between high-ability and typically developing individuals by the total score or the cut-off score of standardized depression scales (Cook et al., 2020; Mishra et al., 2024). This strategy is based on the traditional theory of psychopathology which considers symptoms as observable expressions of a single latent disorder (Beard et al., 2016; Gijzen et al., 2021). The method assigns equivalent weight to all depression symptoms and may obscure important variations among distinct depression symptoms and associations between these symptoms (Fried & Nesse, 2015). Yet Lux and Kendler (2010) explored associations between nine depression symptoms based on the DSM symptomatic criteria of major depression and a wide range of potential risks, and the results showed widely varying associations between individual symptomatic criteria and those risk factors. Consequently, depression symptoms are not equivalent and the heterogeneity among depression symptoms should be further explored at the symptom level, which could help understand the psychopathology underlying depression and identify risk factors more effectively (Cai et al., 2022).

The network theory of psychopathology provides an emerging framework to conceptualize mental disorders, suggesting mental disorders evolve from a complex system developed from dynamic interactions among symptoms (Borsboom, 2017). Network analysis operationalizes this theory and puts symptoms in a network (Borsboom & Cramer, 2013; Zhang et al., 2023). It estimates both the network structure and interconnections among symptoms (Cai et al., 2022; Zhang et al., 2023). This approach also identifies core symptoms in the mental disorder network, which exert the greatest influence on other peripheral symptoms and contribute most to the maintenance of the mental disorder; hence targeting identified core symptoms can yield the most effective treatment outcomes (Borsboom, 2017; Cai et al., 2022; Lunansky et al., 2022).

Network analysis has been widely applied to various mental disorders, including depression, to locate core symptoms. For example, Wang et al. (2023) constructed the depression network with depression symptoms from the Children's Depression Inventory (CDI) in a sample of 610 adolescents and identified anhedonia and negative self-esteem as core depression symptoms. Xie et al. (2023) used three samples of 4375 adolescents to separately identify core symptoms in three depression networks within CDI, Short Mood and Feelings Questionnaire (SMFQ), and Patient Health Questionnaire (PHQ). The results showed that self-hatred and loneliness in CDI, no good and self-hatred in SMFQ, and feeling tired in PHQ were core symptoms in depression networks (Xie et al., 2023). However, the application of network analysis to compare depression symptoms between high-ability and typically developing adolescents appears to be the first of its kind in the literature.

Building on previous research gaps, this study sought a deeper and comprehensive understanding of how depression differs between high-ability and typically developing adolescents. Specifically, (1) we investigated whether high ability in conjunction with gender and cultural factors shape the overall manifestation of depression; (2) we conducted depression network structures separately for high-ability adolescents and their typically developing peers to identify central symptoms for the two adolescent populations; (3) we compared the network structure of depression between the two groups to reveal the association between high ability and depression from a symptom level. The dual approach of assessing the disorder-level and the symptom-level distinction of depression allowed us to thoroughly clarify how high ability influences the presentation and experience of depression.

Methods

Participants and Procedures

This study is a component of a large project investigating mental health in high-ability adolescents across Eastern and Western cultures. This project is designed to respond to the low research attention of high ability populations in East Asia (Cristina et al., 2025; Dagli et al., 2025). The study was approved by the ethics committee of the corresponding author's university when funding support was approved. Potential participants were recruited in Hong Kong, Taiwan, the United Kingdom (UK), and the Netherlands via the online platform Qualtrics. These regions have extended gifted/enriched programs available (Wei et al., 2024). Additionally, Hong Kong and the UK were selected due to their highly comparable education systems between East Asia and Europe but a similar tendency to overlook the development of high-ability adolescents (Forestier et al., 2016). Taiwan and the Netherlands were selected due to their leading development of the high ability education within East Asia and Europe(Chen, 2013; Wolfensberger, 2015; Wu, 2013). The diversity in high-ability recognition and support provides a comprehensive picture for comparison. After providing parental approval and informed consent, participants completed a series of questionnaires on Qualtrics. Qualtrics is a commercial sampling service that utilizes panels comprising individuals recruited through diverse channels, such as emails, word-of-mouth, social media platforms, and online gaming (Chenneville et al., 2023). It is regarded as an acceptable approach for reaching demographically diverse participants within different targeted regions and ensuring

the representativeness of the sample (Chenneville et al., 2023; Miller et al., 2020).

Several quality check procedures were conducted in this study to ensure the data integrity, including attention tests (responding precisely to questions) and speed tests (completing the survey in more than two-thirds of the median time). Questionnaires from participants who failed to pass these tests were excluded. The final sample included 3955 adolescents, consisting of 925 participants from Hong Kong (23.39%), 1045 from Taiwan (26.42%), 1033 from the UK (26.12%), and 952 from the Netherlands (24.07%) (Table 1).

Based on well-established identification approaches in the literature (Chan, 2011; Guignard et al., 2012; Metha & McWhirter, 1997), two criteria were applied to identify high-ability adolescents in this study: (1) being nominated for any gifted/enrichment program; (2) receiving extra support from school as the "more abled" student. These criteria reflect widely accepted methods for recognizing advanced intellectual potential. Nomination to a gifted or enriched program typically involves standardized measures and professional evaluations that confirm elevated cognitive or academic performance. Meanwhile, designation as a "more abled" student acknowledges students who may not be formally enrolled in a gifted program but have nevertheless been recognized by educators for their exceptional abilities. By including both types of identification, the study aimed at a more comprehensive capture of high-ability students while maintaining validity in group classification. Participants who met at least one of these criteria were assigned to the high-ability group. Finally, a total of 1162 participants were identified as high-ability adolescents (Table 1).

It is important to note that while gifted/enrichment program nominations may typically include standardized assessments and professional evaluations, there is variability in the inclusion criteria of gifted/enrichment program from different regions due to different culture and education contexts (Kim et al., 2009). Also, school-based extra support relies more heavily on educator judgment, which can introduce subjectivity due to varying school criteria and implicit biases of high ability.

Table 1 Descriptive statistics of participants' demographics ($n=3955$)

	n	%
Age	$M=16.19$	$SD=1.62$
Regions		
Eastern (Hong Kong and Taiwan)	1970	49.81%
Western (the UK and the Netherlands)	1985	50.19%
Gender		
Male	2227	56.31%
Female	1728	43.69%
High-ability	1162	29.38%

Measures

The Patient Health Questionnaire-9 (PHQ-9)

The PHQ-9 is a self-report scale, which is widely applied to assess individuals' depression severity in the past two weeks (Kroenke et al., 2001). This scale includes nine items measuring the core systems of major depressive episodes in DSM-5. Item responses range from 0 (Not at all) to 3 (Nearly every day). The Chinese and Dutch versions of the questionnaires were translated and back-translated by the research team and language center at Radboud University following the strict protocol by Brislin (1970, 1986). Previous research showed good reliability and validity of the PHQ-9 in both Chinese and European adolescent samples (Liang et al., 2023; Shevlin et al., 2022). In this study, the PHQ-9 demonstrated good internal consistency (The high-ability group: Cronbach's $\alpha=0.885$; the typically developing group: Cronbach's $\alpha=0.906$. The Eastern sample: Cronbach's $\alpha=0.902$; the Western sample: Cronbach's $\alpha=0.887$). The measurement invariance of PHQ-9 across the high-ability and typically developing group was tested, and results indicated a good fit to the data ($\chi^2=451.819$–583.252, $df=54$–79, CFI = 0.969–0.975, TLI = 0.967–0.975, RMSEA = 0.054–0.061, SRMR = 0.024–0.030) and supported the residual invariance (ΔCFI = 0.000–0.006, ΔRMSEA = 0.003–0.004) (see Supplementary Table S1). The measurement invariance of PHQ-9 across the Eastern and Western sample was tested, and results indicated a good fit to the data ($\chi^2=458.003$–1023.171, $df=54$–79, CFI = 0.939–0.974, TLI = 0.944–0.968, RMSEA = 0.059–0.078, SRMR = 0.025–0.049) and supported the scalar invariance (ΔCFI = 0.001–0.007, ΔRMSEA = 0.003) (see Supplementary Table S2). In practice, scalar invariance (invariance of both factor loadings and intercepts) is generally considered sufficient for establishing measurement invariance (An et al., 2017).

The Almost Perfect Scale-Revised (APS-R)

The APS-R is a self-report scale used to measure individuals' perfectionism (Slaney et al., 2001). This 23-item scale consists of three subscales: the Discrepancy subscale, the High Standards subscale, and the Order subscale. Each item is scored on a 7-point Likert scale, ranging from 1 (Strongly disagree) to 7 (Strongly agree). A higher total score on this scale represents a higher level of perfectionism. The Chinese and Dutch versions of the questionnaires were translated and back-translated by the research team and language center at Radboud University following the strict protocol by Brislin (1970, 1986). Previous research showed the good reliability and validity of the APS-R in both Chinese and

European adolescent samples (Chan, 2011; Sastre-Riba et al., 2016).

In this study, the APS-R and three subscales showed good internal consistency (The high-ability group: Cronbach's α of APS-*R* = 0.897, Cronbach's α of Discrepancy = 0.900, Cronbach's α of High Standards = 0.824, Cronbach's α of Order = 0.777; the typically developing group: Cronbach's α of APS-*R* = 0.950, Cronbach's α of Discrepancy = 0.931, Cronbach's α of High Standards = 0.885, Cronbach's α of Order = 0.834. The Easten sample: Cronbach's α of APS-*R* = 0.943, Cronbach's α of Discrepancy = 0.924, Cronbach's α of High Standards = 0.850, Cronbach's α of Order = 0.839; the Western sample: Cronbach's α of APS-*R* = 0.935, Cronbach's α of Discrepancy = 0.921, Cronbach's α of High Standards = 0.855, Cronbach's α of Order = 0.800). The measurement invariance of APS-R and each subscale across the high-ability and typically developing group was tested. Results indicated the APS-R (χ^2 = 3518.217–4317.151, *df* = 454–517, CFI = 0.920–0.936, TLI = 0.922–0.931, RMSEA = 0.054–0.061, SRMR = 0.057–0.061), the Discrepancy subscale (χ^2 = 1194.071–1761.347, *df* = 108–142, CFI = 0.933–0.955, TLI = 0.938–0.950, RMSEA = 0.068–0.076, SRMR = 0.031–0.043), the High Standards subscale (χ^2 = 188.061–357.445, *df* = 28–47, CFI = 0.972–0.986, TLI = 0.975–0.981, RMSEA = 0.050–0.058, SRMR = 0.018–0.034), and the Order subscale (χ^2 = 17.691–51.060, *df* = 4–14, CFI = 0.993–0.997, TLI = 0.992–0.997, RMSEA = 0.027–0.042, SRMR = 0.008–0.017) fit well, and the Discrepancy subscale (ΔCFI = 0.001–0.003, ΔRMSEA = 0.001–0.002) met the scalar invariance, and the APS-R (ΔCFI = 0.001–0.012, ΔRMSEA = 0.000–0.004), the High Standards subscale (ΔCFI = 0.002–0.010, ΔRMSEA = 0.002–0.008) and the Order subscale (ΔCFI = 0.000–0.004, ΔRMSEA = 0.006–0.010) met the residual invariance (see Supplementary Table S1). The measurement invariance of APS-R and each subscale across the Eastern and Western sample was tested Results indicated the APS-R (χ^2 = 4111.793–4980.309, *df* = 454–517, CFI = 0.907–0.924, TLI = 0.909–0.917, RMSEA = 0.063–0.066, SRMR = 0.054–0.058), the Discrepancy subscale (χ^2 = 1314.990–1815.094, *df* = 108–142, CFI = 0.931–0.950, TLI = 0.936–0.943, RMSEA = 0.073–0.077, SRMR = 0.032–0.050), the High Standards subscale (χ^2 = 209.276–392.929, *df* = 28–47, CFI = 0.969–0.984, TLI = 0.972–0.979, RMSEA = 0.054–0.061, SRMR = 0.019–0.034), and the Order subscale (χ^2 = 23.808–233.547, *df* = 4–14, CFI = 0.959–0.996, TLI = 0.965–0.990, RMSEA = 0.047–0.089, SRMR = 0.009–0.040) fit well, and the APS-R (ΔCFI = 0.002–0.003, ΔRMSEA = 0.000–0.001), the Discrepancy subscale (ΔCFI = 0.002–0.004, ΔRMSEA = 0.001–0.003) and the Order subscale (ΔCFI = 0.002, ΔRMSEA = 0.001–0.003) met the scalar invariance, and the High Standards subscale (ΔCFI = 0.001–0.008, ΔRMSEA = 0.002–0.005) met the residual invariance (see Supplementary Table S2). In practice, scalar invariance (invariance of both factor loadings and intercepts) is generally considered sufficient for establishing measurement invariance(An et al., 2017).

Academic Performance

A single item was used to measure participants' perceived academic performance, "How do you perceive your overall academic performance (when compared to your classmates)?" Participants rated on an ordinal response scale with five graded categories, namely Low, Below average, Average, Above average, and High.

Pubertal Time

A single item was used to measure participants' pubertal time for male adolescents and female adolescents respectively, "How old were you when you had your first spermarche or when your voice deepened?" for male adolescents, and "How old were you when you had your first period?" for female adolescents. Participants rated on an ordinal response scale with three graded categories, namely Early pubertal timing (before 12 years of age), On time (between 12 and 13 years of age), and Late pubertal timing (after 13 years of age).

Data Analysis

Data analyses were conducted using R (version 4.2.2) (R Core Team, 2022). Missing data accounted for 0.17% of the data, with 262 missing values out of 150,290 possible values. The missing values were addressed using Multiple Imputation by Chained Equations (MICE) implemented in the R package *mice* (Van Buuren & Groothuis-Oudshoorn, 2011).

ANCOVA Analysis

The ANCOVA was conducted to explore the interaction effects of high ability * gender, high ability * region, and region * gender on adolescents' depression. Perfectionism, academic performance, age, and puberty time were entered as covariates in the ANCOVA model to control their effects on results. Effect sizes of principal comparisons were computed using the partial eta squared (η^2) statistic.

Network Analysis

Network analysis was conducted to explore the depression network in the high-ability group and the typically developing group respectively.

Pre-analysis Redundant nodes in the network can lead to biased results. The goldbricker function from the R package *Networktools* was utilized to check the potential redundancy of nodes (threshold: 0.25) (Jones, 2018) and results suggested no redundant nodes in this study. Therefore, all items of the PHQ-9 were included in the network analysis.

Network Estimation The R package *qgraph* was utilized to calculate and visualize the depression networks in the high-ability group and the typically developing group (Epskamp et al., 2012). The network structures were estimated using EBICglasso regularisation with a default Extended Bayesian Information Criterion tuning parameter of 0.5 (Epskamp et al., 2018). The EBICglasso was chosen to construct networks due to the continuous data and relatively high sample size (about or above 1000) in this study (Isvoranu & Epskamp, 2023). In the network, symptoms were identified as nodes while connections between nodes were identified as edges. Each edge has edge weight which indicates the strength of the connection between the two nodes (Liu et al., 2024). In the network plots, the edge weights were visualized as the thickness of edges with wider edges indicating stronger connections.

Network Centrality The central nodes have many strong connections with other nodes in the entire network and therefore have great effects on the network (Liu et al., 2024). The centralityPlot function from the R package *graph* was utilized to calculate centrality indices (Epskamp et al., 2012). According to Bringmann et al. (2019), the centrality indices strength and expected influence (EI) are more reliable than other centrality indices. Thus, in this study, strength and EI were calculated to describe the importance of each node in the network. Strength is the sum of all absolute edge weights to which a node is connected, and EI is the sum of edge weights to which a node is connected considering both the strength and directions of edges (Epskamp et al., 2018).

Network Stability The R package *bootnet* was utilized to estimate the stability and accuracy of the network (Epskamp et al., 2018). The case-dropping bootstrap test ($n=1000$) was performed to estimate the stability of the centrality indices, which was quantified by the correlation stability coefficient (CS-coefficient). The CS-coefficient represents the maximum proportion of the sample that can be dropped while maintaining a 95% probability of a high correlation ($r \geq 0.7$) with the original data set (Epskamp et al., 2018). The CS-coefficient must be above 0.25 and is ideally higher than 0.5 (Epskamp et al., 2018). Additionally, the bootstrap confidence interval (CI) test was conducted to assess the accuracy of edge weights (Epskamp et al., 2018). Narrower CIs indicate low sampling variability in edge-weights, implying a trustworthy network (Mullarkey et al., 2019).

Network Comparison The R package *Network Comparison Test* was utilized to test differences in the depression network between the high-ability group and the typically developing group (van Borkulo et al., 2023). The following tests were conducted to compare the depression networks: the global strength invariance test was performed by comparing the sum of the edge strength; the network structure invariance test was performed by comparing the distributions of edge weights; the edge invariance tests were performed by comparing the edge weight of each edge in the network; the centrality invariance tests were performed by comparing the centrality of each node in the network (van Borkulo et al., 2023). In addition, the Holm-Bonferroni correction was applied to check differences in the edge weight of each edge and the centrality of each node between the two networks for multiple comparisons.

Table 2 Results of ACNOVA ($n=3955$)

Variable	η^2	F	p
High ability	0.008	36.726	***
Gender	0.008	37.638	***
Region	0.059	264.926	***
High ability * Gender	0.001	4.065	0.044*
High ability * Region	0.000	0.956	0.328
Gender * Region	0.006	25.048	***
Academic performance	0.030	33.495	***
Age	0.001	4.401	0.036*
Pubertal time	0.002	10.703	0.001**
Perfectionism	0.007	32.236	***

Results

Main and Interaction Effects of High-ability, Gender, and Region on Depression

The ANCOVA results were shown in Table 2. Significant main effects of high ability, gender, and region were observed on depression (High ability: $F=36.726$, $p<0.001$; Gender: $F=37.638$, $p<0.001$; Region: $F=264.926$,

$p<0.001$). Specifically, high-ability students ($M=1.123$, $SD=0.024$) had higher depression than typically developing students ($M=0.976$, $SD=0.018$); females ($M=1.080$, $SD=0.022$) had higher depression than males ($M=1.020$, $SD=0.020$); adolescents in Western regions ($M=1.235$, $SD=0.021$) had higher depression than adolescents in Eastern regions ($M=0.863$, $SD=0.021$).

High ability and gender had a significant interaction effect on depression ($F=4.065$, $p<0.05$) (see Fig. 1). The result indicated that females ($M=1.175$, $SD=0.032$) had higher depression than males ($M=1.070$, $SD=0.030$) in the high-ability group ($p<0.01$), but no significant difference in the depression between females ($M=0.990$, $SD=0.023$) and males ($M=0.961$, $SD=0.022$) in the typically developing group ($p=0.285$). Region and gender had a significant interaction effect on depression ($F=25.048$, $p<0.001$) (see Fig. 2). The result indicated that females ($M=1.323$, $SD=0.027$) had higher depression than males ($M=1.148$, $SD=0.026$) in Western regions ($p<0.001$), but no significant difference in the depression between females ($M=0.842$, $SD=0.029$) and males ($M=0.883$, $SD=0.025$) in Eastern regions ($p=0.208$).

Network Analysis Results

Network Structure and Centrality of the High-ability Group

The network structure of depression in the high-ability group was displayed in Fig. 3. Of 36 possible edges, there were 35 non-zero edges, resulting in a mean weight of 0.109.

The strength and EI centrality were shown in Fig. 4. The symptom D2 *"feeling depressed"* was the most central node (strength = 0.986, EI = 0.986), followed by the symptom D1 *"losing interest"* (strength = 0.904, EI = 0.904) and D6 *"self-deprecation"* (strength = 0.904, EI = 0.904) (see Table 3).

Accuracy and Stability Estimation of the Depression Network in the High-ability Group The results of edge-weights with bootstrapped CIs were shown in Supplementary Figure S1, and the 95% CIs for bootstrapping are narrow (the mean width of CIs is 0.122, the range of CI widths is 0.097–0.137) (see Supplementary Table S3). The narrow mean width of CIs and small range of CI widths suggested the low sampling variability in edge-weights, indicating the reliable and accurate estimation for the edge weights (Mullarkey et al., 2019). The case-dropping bootstrapping suggested strength

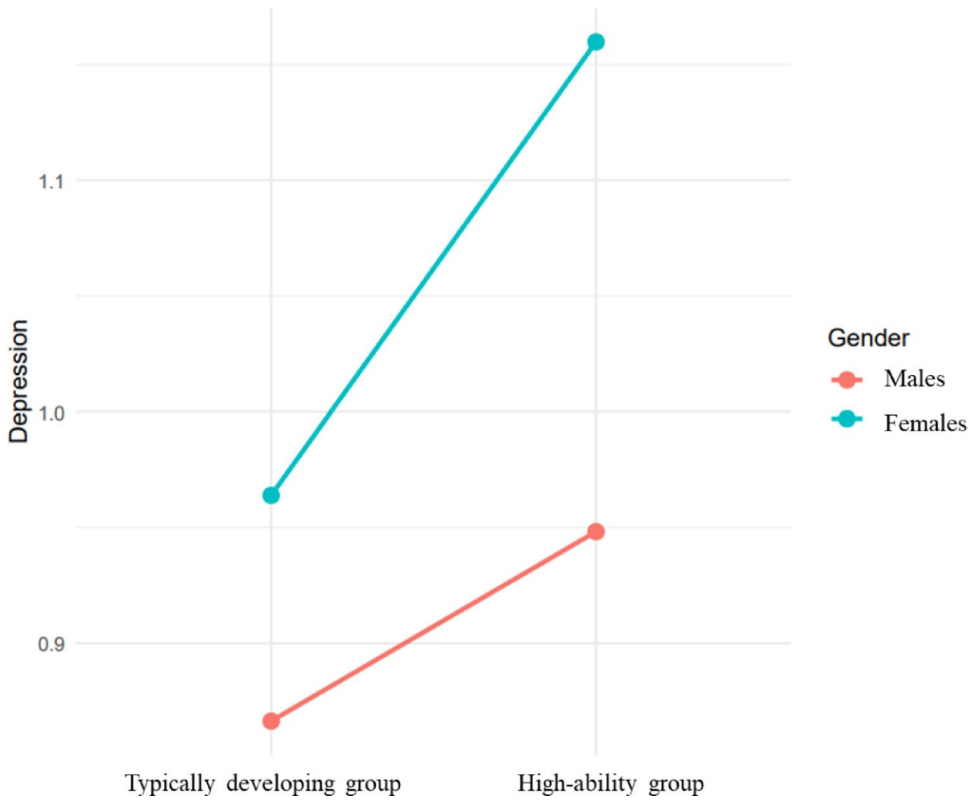

Fig. 1 The interaction effect between high ability and gender on depression ($n=3955$)

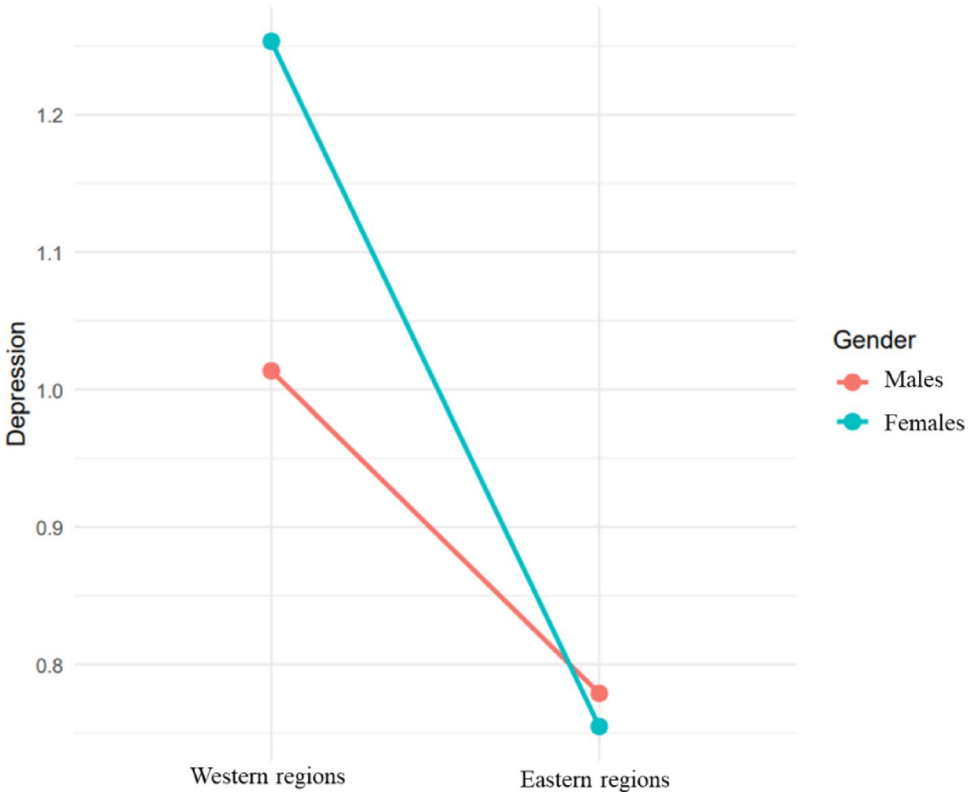

Fig. 2 The interaction effect between region and gender on depression ($n = 3955$)

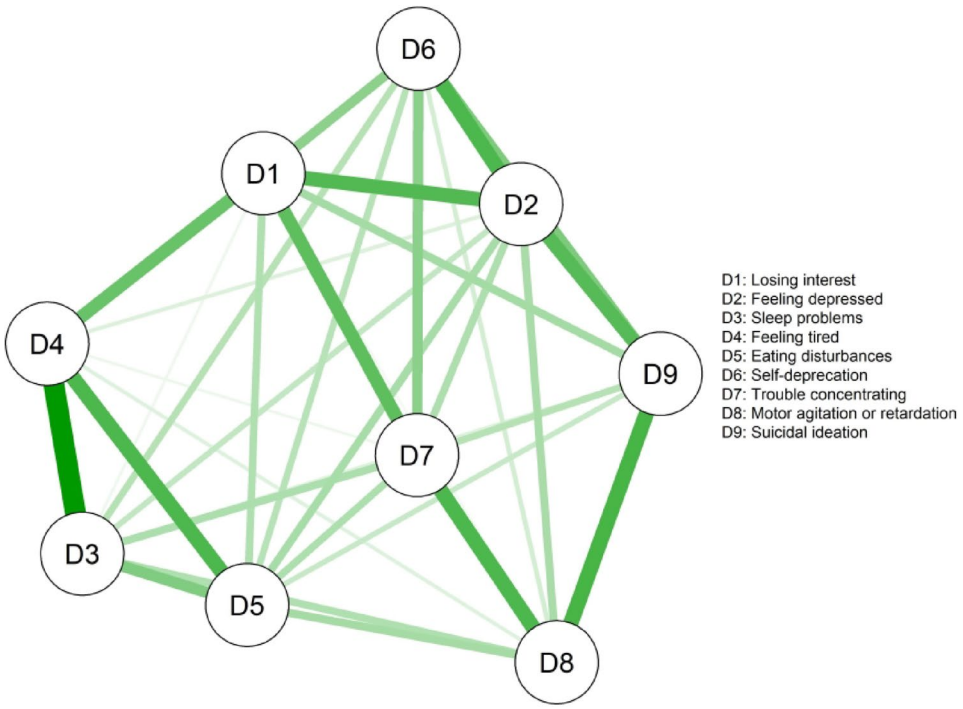

Fig. 3 Network structure of depression in the high-ability group ($n = 1162$)

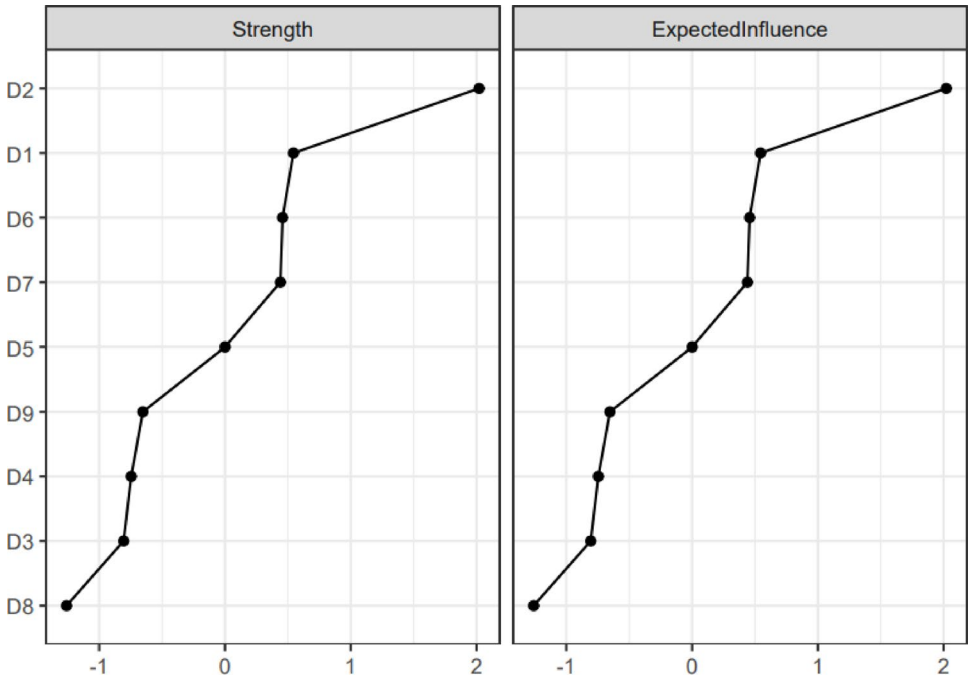

Fig. 4 Centrality plot of depression network in the high ability group ($n=1162$)

Table 3 Summary of core symptoms and peripheral symptoms across the high ability group ($n=1162$) and the typically developing group ($n=2793$)

The high ability group	The typically developing group	Core/Peripheral symptom
D2: Feeling depressed	D2: Feeling depressed	Core symptom
D1: Losing interest	D6: Self-deprecation	Core symptom
D6: Self-deprecation	D4: Feeling tired	Core symptom
D7: Trouble concentrating	D1: Losing interest	Peripheral symptom
D5: Eating disturbance	D5: Eating disturbance	Peripheral symptom
D9: Suicidal ideation	D7: Trouble concentrating	Peripheral symptom
D4: Feeling tired	D9: Suicidal ideation	Peripheral symptom
D3: Sleep problems	D3: Sleep problems	Peripheral symptom
D8: Motor agitation or retardation	D8: Motor agitation or retardation	Peripheral symptom

and EI had relatively low but acceptable stability with the CS-coefficients of 0.439 (see Supplementary Figure S2).

Network Structure and Centrality of the Typically Developing Group

The network structure of depression in the typically developing group was displayed in Fig. 5. Of 36 possible edges, there were 35 non-zero edges, resulting in a mean weight of 0.112.

The strength and EI centrality were shown in Fig. 6. The symptom D2 *"feeling depressed"* was the most central node (strength = 0.982, EI = 0.982), followed by the symptom D6 *"self-deprecation"* (strength = 0.969, EI = 0.969) and D4 *"feeling tired"* (strength = 0.934, EI = 0.934) (see Table 3).

Accuracy and Stability Estimation of the Depression Network in the Typically Developing Group The results of edge-weights with bootstrapped CIs were shown in Supplementary Figure S3, and the 95% CIs for bootstrapping are narrow (the mean width of CIs is 0.086, the range of CI widths is 0.055–0.095) (see Supplementary Table S3). The narrow mean width of CIs and small range of CI widths suggested the low sampling variability in edge-weights, indicating the reliable and accurate estimation for the edge weights (Mullarkey et al., 2019). The case-dropping bootstrapping suggested strength and EI remained stable with the CS-coefficients of 0.672 and 0.750 (see Supplementary Figure S4).

There is no established standard for determining the number of core symptoms or the cutoff values for strength and expected influence (EI) centrality in network analysis. The selection of the three core symptoms in this study was based on previous research concerning depression networks (Suo et al., 2025; Xie et al., 2023).

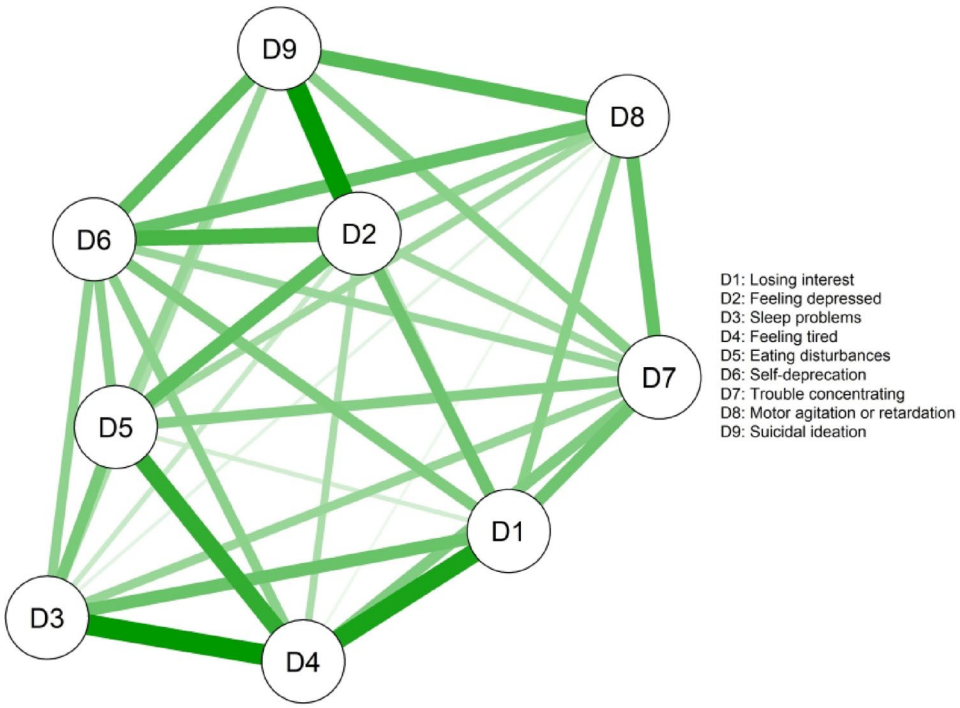

Fig. 5 Network structure of depression in the typically developing group ($n = 2793$)

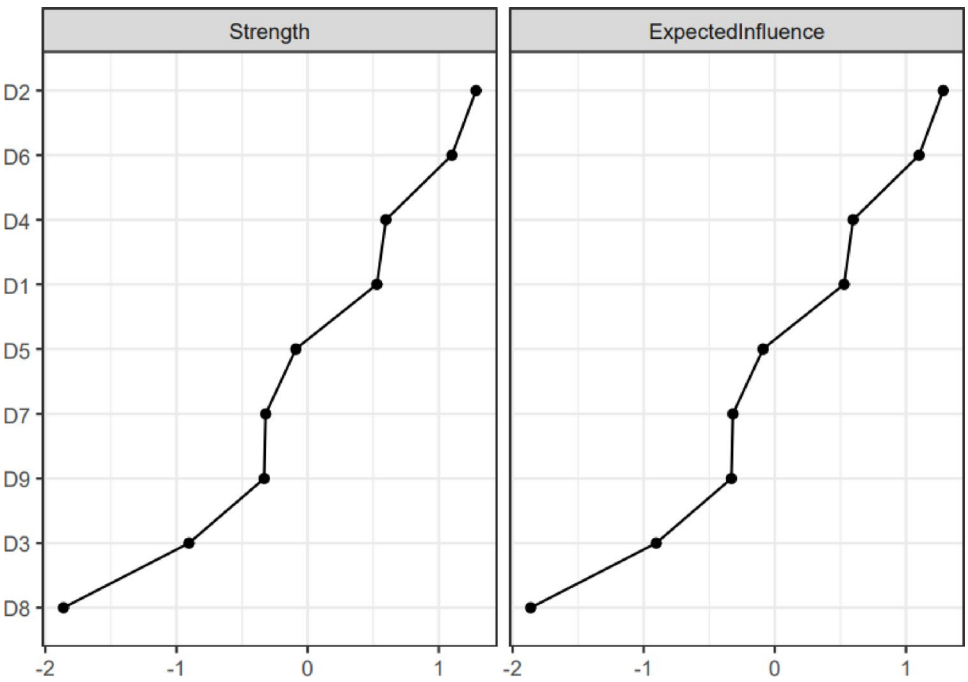

Fig. 6 Centrality plot of depression network in the typically developing group ($n = 2793$)

Network Comparison Between the High-ability and Typically Developing Group

The structure invariance test showed no significant difference in the network structure of the two networks. The global strength invariance test showed the global strength of the typically developing group was greater than the high-ability group ($M_{typical} = 3.993$, $M_{high-ability} = 3.870$, $p < 0.01$). The differences in edge weight of each edge and the centrality of each node were tested after the Holm-Bonferroni correction, and results showed no significant differences in the edge weight or node centrality.

Discussion

This study explored the less studied association between high ability and depression in a large adolescent sample from Eastern Asia and Europe. It bridged the research gap of previous research regarding high-ability individuals' depression, which mostly obscured potential demographic variations in the association between high ability and depression (Duplenne et al., 2023; Karpinski et al., 2018; Mishra et al., 2024; Plominski & Burns, 2017). Furthermore, the current study was the first study to compare depression networks between high-ability adolescents and their typically developing peers. The findings of this study could provide a more comprehensive understanding of the association between high ability and adolescents' depression from both the disorder level and the symptom level, as well as contribute to the tailored depression interventions in different adolescent subgroups.

For the disorder level, the main effects of high ability, gender, and region on adolescents' depression were significant, even after controlling their perfectionism, age, pubertal time, and academic performance. In line with the theory of positive disintegration and some prior research findings, this study found that high-ability adolescents had higher depression than their typically developing peers (Bénony et al., 2007; Dąbrowski, 1976; Karpinski et al., 2018). Adolescents with higher academic abilities might report depressive symptoms as they tend to compare themselves with peers with better academic abilities, which in turn, impairs their self-worth and depletes their academic performance – a condition also touted as the "big-fish-little-pond effect"(Dai & Rinn, 2008). This finding supported the view that high ability might be a potential risk factor for adolescents' depression.

Further, high-ability adolescents' increased vulnerability to depressive symptoms might be explained by their interpersonal sensitivity and weakness in social skills (Al-Rousan et al., 2025; Mueller, 2009) – conditions that impair their satisfaction with social interactions and well-being outcomes relative to their typically developing peers (Kroesbergen et al., 2015; Vialle et al., 2007), which are related to lower well-being and increased depression. Karpinski et al. (2018) proposed that high-ability individuals were more likely to engage in rumination and worry in response to environmental stressors, which could positively predict the risk for psychological over-excitabilities causing affective disorders. Future studies can explore multi-accounting for the relationship between giftedness and depression.

The interaction effect of gender and high ability on adolescents' depression was found to be significant at a marginal level, which corroborated prior research by Mishra et al. (2024). One possible explanation is that high-ability females tend to face a conflict between traditional views of gender roles (e.g., females' inferiority in math and science, females' traditional career orientation) and their personal ambitions, which may contribute to high-ability female adolescents' increased depression compared to their male counterparts (Fiebig, 2008; Kerr & Multon, 2015; Ogurlu et al., 2018). The significant interaction effect between gender and regions on depression may reflect greater social support from family and peers in Chinese collectivism culture can help individuals eliminate depression, particularly in females with high interpersonal sensitivity, which further contribute to reduce the gender difference in Chinese adolescents' depression (Li & Hao, 2025; Yin et al., 2017; Zhang & Han, 2023).

For the symptom level, the *feeling depressed* and *self-deprecation* were identified as core symptoms in both the high-ability group and the typically developing group. The findings aligned with previous studies (Wasil et al., 2020; Xie et al., 2023) on the core symptoms of depressed mood and self-deprecation in adolescents' depression. The centrality of *feeling depressed* aligns with the theoretical conceptualization of depression which emphasizes the importance of sad mood in depressive symptomatology, as well as previous research on adolescents' depression network regardless of which depression scale was used (Leahy, 2002; Wasil et al., 2020; Xie et al., 2023). The *self-deprecation* can also be a central symptom in the depression network of adolescents. Individuals are often encouraged to reflect on themselves and others' perceptions of them in adolescence (Steinberg, 2005). For typically developing adolescents, they might be vulnerable to developing low self-efficacy and negative self-image due to their academic underachievement compared with their high-ability peers, which may lead to self-deprecation and depression (Muntean et al., 2024). For high-ability adolescents, self-introspection might also be pronounced due to the heightened social expectations they face (Reis & McCoach, 2000). Then, self-deprecation might be formed along with high-ability adolescents'

perfectionism in self-reflection (Neshat et al., 2024), which has a great impact on the depression network.

Notably, there are also some differences in core symptoms of the depression network between high-ability adolescents and typically developing adolescents. *Losing interest* was identified as the unique central symptom of the high-ability adolescents' depression network. Losing interest or pleasure signifies individuals' inability to experience pleasure, which can lead to depressed mood (Wang et al., 2023). Our study provided empirical evidence on previous postulation that high-ability adolescents are more likely to experience existential depression, which arises from individuals' concerns about existential issues or life meaning (Rodríguez-Fernández & Sternberg, 2024). They tend to ask meaning-seeking questions (e.g., why do we live? The origin of everything) that others might not, and then they may feel frustrated and lose pleasure when recognizing that others do not explore those concerns as deeply as they do (Bowers, 2007; Rodríguez-Fernández & Sternberg, 2024). This finding highlights the potential of losing interest as a predictor of future depression in high-ability adolescents. It also suggests the importance of including existential elements and helping high-ability adolescents recapture interests and pleasure in interventions for them. For example, mindfulness techniques can evoke mental presence, which can be connected to giftedness in interventions to help those high-ability adolescents experiencing existential suffering (Turanzas et al., 2020).

The *feeling tired* was identified as the unique core symptom in the typically developing group. Previous investigations by Gijzen et al. (2021) and Liang et al. (2023) also identified *feeling tired* as a core symptom in adolescents' depression. Typically developing adolescents might more likely be overwhelmed with various challenges, including physical changes, future uncertainties, and heightened academic demands, contributing to their fatigue (Tikkanen, 2016).

In addition, the network comparison results showed that the global strength of the depression network in typically developing adolescents was greater than high-ability adolescents, indicating tighter interactions of depression symptoms among typically developing adolescents (van Borkulo et al., 2023). This could be attributed to any activation within the depression system rapidly leading to the co-occurrence of other depression symptoms in typically developing adolescents (Su et al., 2024).

Furthermore, global strength reflects the overall connectivity of the network, calculated as the weighted absolute sum of all edges, and differences in this metric can highlight broader patterns of symptom interdependence even when individual edge differences do not reach statistical significance after multiple comparison corrections (van Borkulo et al., 2023). Thus, the observed difference in global strength might be influenced by a subset of connections, particularly those involving somatic symptoms (e.g., sleep problems—losing interest, feeling tired—trouble concentrating), which showed numerically larger weight discrepancies between typically developing adolescents and their high-ability peers, though these were not statistically significant after Holm-Bonferroni correction (see Supplementary Table S3). Future studies could replicate the network differences in larger samples. Previous research by Rice et al. (2019) posited that somatic symptoms (e.g., sleep problems, feeling tired, motor agitation or retardation) were common in adolescents' depression, and our finding may further suggest that somatic symptoms exert great impacts on the maintenance of the depression network among typically developing adolescents rather than high-ability adolescents. It might be because some characteristics of giftedness, such as conscientiousness and self-control, can help high-ability adolescents maintain balanced habits, relating to their high sleep quality and low fatigue, which then contributes to alleviating their somatic symptoms (Bland et al., 1994; Demirhan et al., 2018).

Implications

Practical Implications

Consistent with previous studies (Bénony et al., 2007; Karpinski et al., 2018), our study showed that high-ability adolescents were found to have elevated depression levels compared to their typically developing peers. This result underlines the need for social workers, clinicians and educators to be attentive to potential mental health risks in high-ability youth, rather than assuming that high academic or intellectual performance correlates with psychological well-being. Social workers can implement evidence-based to reduce isolation and foster shared experiences among high-ability adolescents (Pfeiffer, 2013), modeling appropriate social interactions to address common challenges like asynchronous development or perfectionism (Fındık & Afat, 2023), and collaborating with schools to integrate social-emotional learning programs that prioritize high-ability students' needs (Wiley, 2020). High-ability adolescents warrant policies advocated to explicitly recognize them as a population with potential depression vulnerabilities and promote public awareness that challenges the potential myth or misunderstanding about high-ability individuals' mental health problems. Although the interaction effect of high ability and gender was marginal, results still suggest that high-ability female adolescents exhibit higher depression levels than their male counterparts. However, existing psychological interventions for high-ability children tended

to neglect the gender difference (Turanzas et al., 2020), and clinicians may enhance these interventions by incorporating modules that address gender-specific factors, such as rumination, stress response, and interpersonal sensitivity. Social workers and school psychologist should also consider and address potential gender-specific reasons for depression in high-ability female adolescents (e.g., inner conflict between traditional gender roles and personal ambitions) when working with them (Fiebig, 2008; Kerr & Multon, 2015; Ogurlu et al., 2018). Adolescents from Western regions reported higher depression than those from Eastern regions, potentially due to differences in measurement sensitivity (Zhou et al., 2020). Social workers working with culturally diverse groups should consider that cultural norms and values might influence both the expression and measurement of depressive symptoms, in particularly the manifestation of depression through somatic complaints rather than emotional symptoms. Culturally sensitivity training for social workers and collaborations with community interpreters for personalized identification and treatment are needed. Gender differences in depression, which were evident in Western but not Eastern contexts, further highlight the need for culturally nuanced assessment and intervention. Yet, some of these effects are small although the finding is statistically robust (e.g., the main effect of gender, the interaction effect between gender and high ability). Though they suggest the limited practical and clinical influence (Ferguson, 2009) in the sample, the small effect might have massive implications when scaled across a large population in future studies.

Network analysis identified *feeling depressed* and *self-deprecation* as central symptoms in both groups, whereas *losing interest* emerged as an additional core symptom in the high-ability group and *feeling tired* was a unique core symptom in the typically developing group. According to these core symptoms, social workers and school psychologists can identify potential unique presentations of depression for high-ability adolescents and typically developing adolescents and conduct early precise interventions, as these symptoms can play a pivotal role in maintaining depressive networks (Gijzen et al., 2021; Liang et al., 2023). Specifically, given the centrality of negative emotional and self-perception features in the symptoms for both high-ability and typically developing groups, social workers, school psychologists, clinicians, and educators may consider adopting strength-based strategies that can protect such vulnerable adolescent groups from maladaptive psychological states. For example, as past studies have shown the psychological benefits of socially oriented strengths such as kindness, love, and social intelligence in Chinese children and adolescents (Datu, 2025; Datu & Fung, 2023), school psychologists and clinicians may design school-wide psychological interventions centered on these strengths to reduce students' self-deprecation and prevent students from experiencing depression and other psychopathological conditions.

Further, social workers and school psychologists can tailor intervention strategies to address unique core symptoms for high-ability adolescents and typically developing adolescents respectively, which may be more effective than one-size-fits-all initiatives. For example, existential therapy can be further explored to help high-ability adolescents address existential issues and recapture interests based on the unique core symptom *losing interests* in high-ability adolescents (Lybbert et al., 2019), while physical fatigue and sleep disturbances can be considered as targeting intervention symptoms in standard adolescent populations based on the unique core symptom *feeling tired* in typically developing adolescents (Gijzen et al., 2021; Liang et al., 2023).

Theoretical Implications

Prior studies often focused on high-ability samples from various age groups without systematically considering demographic factors like gender and culture (Duplenne et al., 2023; Karpinski et al., 2018; Mishra et al., 2024; Plominski & Burns, 2017). This study helps fill that gap by examining a large, culturally diverse adolescent sample and identifying how high ability, gender, and cultural context jointly influence depression.

By incorporating both ANCOVA and network analysis, the research illustrates how high ability contributes to the overall risk for depression (disorder level) and reveals specific symptoms that maintain and propagate depressive states (symptom level). This dual focus refines our theoretical understanding of depression (e.g., Dąbrowski's theory of positive disintegration) by showing that high ability is not only correlated with increased depressive symptomatology but also with unique symptom interconnections (e.g., losing interest). Although perfectionism and academic performance were controlled, high-ability adolescents still exhibited higher depression, suggesting that additional mechanisms (e.g., rumination, heightened sensitivity) likely underpin the association between high ability and mood disorders. Future theoretical models might integrate these interpersonal and cognitive factors to account for the heightened risk observed in high-ability adolescents (Karpinski et al., 2018). The distinction in network strength between high-ability and typically developing adolescents—with stronger interconnections among the latter—encourages a more nuanced, network-oriented view of psychopathology, where certain adolescent subgroups have distinctive pathways into and out of depression.

Limitations and Future Directions

Our research has a number of conceptual and methodological limitations. Firstly, our study's cross-sectional design makes it difficult to establish directional depression networks for high-ability adolescents and typically developing adolescents. Future longitudinal research can construct directed networks in high-ability adolescents and typically developing adolescents to investigate causal links among depression symptoms. Secondly, the generalizability of findings might be limited by sample recruitment and sample characteristics. While growing evidence suggests online-panel samples can rival traditional recruitment methods in the representativeness of samples (Miller et al., 2020), using online Qualtrics in our study inevitably excluded individuals without Internet access and might lead to a biased sample (Chenneville et al., 2023). The sample of this study is from a community sample, and it is limited to generalize these results to clinical samples. Future studies can benefit from exploring these relationships in clinical samples and provide more effective guidance for depression interventions. Further, high-ability adolescents are identified by nominations from gift/enrich programs or extra support from schools. While these approaches were well-structured in previous studies (Chan, 2011; Guignard et al., 2012; Metha & McWhirter, 1997), the identification of high-ability adolescents could be influenced by educators' subjective biases and the differences in inclusion criteria of high ability in specific programs and schools. Future studies can adopt more stringent and consistent criteria (e.g., IQ, concrete creative products, and outstanding performance in specific talent domains) on top of teacher nomination in recruiting samples to achieve further psychometric rigor in identifying high-ability adolescents. In addition, our participants were from different cultural contexts, and there might be some potential cultural biases in understanding and reporting symptoms. Thus, it would be prudent to exercise caution when generalizing the results. Thirdly, our study relied on self-report approaches, which might provide biased results (e.g., social desirability, recall inaccuracy). Relatedly, academic performance and pubertal time were assessed using single-item measures, which might have lower reliability and validity compared to multi-item scales. Future cross-replication studies can apply multi approaches to obtain more robust results, including observation, clinical interviews and reports from parents and teachers. Fourthly, network analysis is a strongly exploratory and data-driven approach (Xie et al., 2023). It should be acknowledged that the current study was exploratory in nature and might have a risk of overfitting. Finally, the network analysis in this study initially explored the depression networks of high-ability adolescents and typically developing adolescents. The effects of gender, region, perfectionism, academic performance, pubertal time, and age on adolescents' depression were found to be significant in the ANCOVA, which were not considered in the network analysis. Future studies can compare the depression networks between high-ability adolescents and typically developing adolescents in different subgroups (e.g., females, Western culture, early adolescence) to capture a more systematic understanding.

Conclusion

Existing literature provides inconclusive insights into the proneness of gifted and high-ability adolescents to psychopathological conditions such as depression. This research contributes to this scientific discourse by showing that female, Western and high-ability adolescents are more susceptible to reporting depression. Concerning specific depressive symptoms, this study demonstrated that *feeling depressed* and *self-deprecation* operate as central symptoms of depression in both high-ability and typically developing adolescents. Further, whereas *losing interest* serves as the unique central symptom in high-ability adolescents, *feeling tired* functions as the unique central symptom in typically developing adolescents. Our findings highlight that high ability might operate as a risk in adolescents' depression. Our research emphasizes the importance of tailoring interventions for high-ability adolescents and typically developing adolescents based on their unique central symptoms. Indeed, more scientific investigations are warranted to enrich our understanding of the psychological health of gifted and high-ability adolescents, especially in underrepresented cultural contexts.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10560-025-01049-3.

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Data Availability Data and study materials are available from the corresponding author on reasonable request.

Declarations

Competing Interests The authors declare no competing interests.

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