



OPEN Evaluating the Tree Drawing Test Depression Assessment Scale for adolescent depression screening

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To assess the effectiveness of the Tree Drawing Test Depression Assessment Scale in screening for depressive disorders among adolescents. This study adopted a case–control design involving 50 adolescents diagnosed with depressive disorders and 54 healthy controls. Participants were administered the Tree Drawing Test (TDT), a subjective projective assessment tool that evaluates psychological states through the analysis of individually drawn tree images. In addition, computerized image recognition and data acquisition technologies were employed. The Tree Drawing Depression Assessment Scale was used for evaluation, and the results were subjected to statistical analysis. The total score differences between the depression group and the control group were statistically significant ($p < 0.001$). With a cutoff score of 13, the Youden Index was 0.761, sensitivity was 0.780, specificity was 0.981, and the positive and negative predictive values were 0.952 and 0.839, respectively. The Cohen's Kappa coefficient between the two raters ranged from 0.753 to 0.977. The Tree Drawing Depression Assessment Scale demonstrates good screening efficacy and effectively distinguishes adolescents with depressive disorders from healthy controls. It can serve as a preliminary screening tool for adolescent depression. However, this study has certain limitations, including a relatively small sample size and the absence of consideration for cultural differences, which may affect the generalizability of the findings. Future research should expand the sample size and examine the tool's applicability across different cultural contexts.

Keywords Projective test, Depressive disorder, Adolescent depression, Depression screening, Reliability and validity testing

Adolescent Depressive Disorder refers to depressive disorders occurring during adolescence, with primary symptoms such as unhappiness and loss of interest. Many studies have shown that, since the beginning of the twenty-first century, the incidence and detection rates of adolescent depressive disorders have increased significantly^{1,2}. In China, the overall detection rate of depressive symptoms in children and adolescents reached 28.4% around 2020, which is a marked increase compared to previous reports of depressive symptom detection rates^{3,4}. These findings suggest that mental health issues, such as depression, anxiety, self-harm, and suicide, among adolescents are rising rapidly^{5–7}. Depression can cause a series of personal, family, and societal harms⁸, with potential long-lasting effects on individuals' psychological well-being, continuing into adulthood and leading to problems in family and marital relationships^{1,2}. However, a significant challenge remains: many adolescents with depression do not receive treatment early, or are even undiagnosed⁹.

Regarding early assessment of adolescent depression, common methods include teacher evaluations in schools, family assessments, self-reports, and interviews. However, some studies have found that the results from these multiple assessment methods are not always consistent with each other¹⁰, leading to inaccurate evaluation outcomes¹¹. Previous research has reported the use of various depression screening tools in adolescents, most of which are self-report scales, such as the BDI and PHQ. However, the performance of these tools varies significantly across different studies, and the results of depression screenings should be interpreted with caution¹². Currently, depression screening scales remain reliable tools for assessing depressive symptoms in adolescents, but some researchers have found that these scales have moderate positive predictive values, indicating the presence of false

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positives. This reflects a limitation of these scales: the test's objectives are easily recognizable, leading to potential false responses driven by the desire to appear "correct"^{7,13}.

As a subjective projective test, the Drawing Projective Test, which analyzes content such as personality and the subconscious through drawings, has the advantage of not requiring verbal expression and can genuinely reflect a person's psychological state¹⁴. This makes it particularly suitable for application among adolescents. Drawing projective tests have a long history of application and have been widely employed in various forms of psychological evaluation and diagnosis. Early research indicates their value in assessing unconscious content, emotional states, and psychological stress. Compared to traditional interviews and self-report questionnaires, drawing-based assessments can offer deeper insights into an individual's inner world through the creative process itself. This feature is especially advantageous in adolescent populations, who may lack fully developed verbal communication skills or may be reluctant to express their emotions.

In clinical practice, the Tree Drawing Test, as a type of projective drawing test, has been extensively studied. This test requires the subject to draw a tree, and its psychological state is inferred by analyzing the tree's form, proportions, details, and other characteristics. Existing research has demonstrated that the Tree Drawing Test plays a significant role in the auxiliary diagnosis of various conditions, including schizophrenia, manic episodes, anxiety disorders, personality disorders, and Alzheimer's disease^{5,15–19}. For example, some researchers have used the Tree Drawing Test to assess the suicide risk among prison populations and found that certain characteristics of the tree were associated with suicidal behavior²⁰. Regarding the correlation between the Tree Drawing Test and depression, numerous studies have shown that certain features in the drawings are linked to depressive symptoms. For instance, individuals with depression tend to draw trees with a monotonous shape, narrow trunks, and possibly a lack of vitality, reflecting emotional suppression and helplessness^{5,21,22}. These findings provide preliminary evidence for the potential role of the Tree Drawing Test in the auxiliary diagnosis of depression. However, despite these studies offering theoretical support for the use of the Tree Drawing Test in depression screening, most research has focused primarily on the analysis of individual features, lacking a systematic integration and standardization of the various indicators of the test. Building on previous studies that explored the correlation between the Tree Drawing Test and depression^{23,24}, the research team proposed an approach to integrate multiple indicators associated with depressive symptoms and developed a Tree Drawing Projective Test Depression Assessment Scale. The purpose of this scale's development is to enhance the value of the Tree Drawing Test in adolescent populations and, through systematic analysis of indicators, improve the accuracy of depression screening. To test the effectiveness of this scale in screening for depressive symptoms in adolescents, this study was conducted with the aim of providing assistance in the screening and prevention of depressive symptoms in adolescents.

Methods

This study was conducted at the Suzhou Mental Health Center in Suzhou, China. Participants were recruited from the inpatient wards for the depressive disorder case group and from the community for the healthy control group. The study was approved by the Medical Ethics Committee of Suzhou Guangji Hospital (Approval No.: 2021-012), all methods were performed in accordance with the relevant guidelines and regulations. All participants were fully informed of the study's purpose and procedures before enrollment and provided written consent to participate. Recruitment occurred from February 2021 to June 2022.

Participant recruitment

Case group

Participants met the DSM-5 diagnostic criteria for depression, aged 12 to 17 years, with no gender restriction²⁵. The Hamilton Depression Rating Scale (HDRS-21) score was ≥ 21 ²⁶.

Control group

Healthy controls were recruited from the same region and enrolled during the same period (2021–2022). Inclusion criteria: No depressive symptoms (as per DSM-5 diagnosis), no obvious psychiatric symptoms (SCL-90 without positive factors), no history of mental illness, and matched with the case group in terms of gender, age, and other demographic characteristics.

Measures

Tree drawing test

Each participant was provided with A4 paper and a black or dark blue pen. The following instructions were given:

- (1) The projective drawing test is not a test of drawing skills, and the quality of the drawing is not important.
- (2) The test is not a life drawing; the picture does not need to match real-world objects.
- (3) If the participant cannot draw what they want, they may draw a circle and write the Chinese characters for it.
- (4) Before drawing the tree, close your eyes and meditate for half a minute. Draw the tree that appears during meditation. If no tree appears, open your eyes and draw the tree you most want to draw.
- (5) After completing the drawing, write your age and gender on the paper²⁴. (Due to cultural differences in the assessment and interpretation of the Tree Drawing Test, this study is limited to participants from mainland China. The participants' cultural background may influence the form and symbolic meaning of the tree depicted, and therefore, the potential impact of cultural background on the drawing content should be considered when interpreting the results²⁷).

	Patients with depression (n = 50)	Normal control group (n = 54)	Test statistic	p-value
Age(M/SD)	15.00(1.39)	14.80(1.43)	t = 0.736	0.46
Gender (n/%)			$\chi = 0.027$	0.87
Male	35(70)	37(68.9)		
Female	15(30)	17(31.5)		

Table 1. Comparative analysis of intergroup differences in depression assessment.

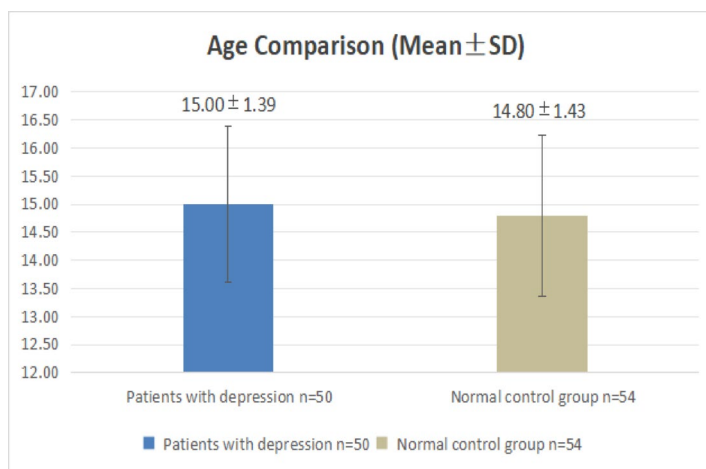


Fig. 1. Intergroup age comparisons.

Tools

Epson high-resolution scanner (DS-1630)

The tree drawings were scanned using an Epson high-resolution scanner (DS-1630) and the images were saved on a computer.

Tree Drawing Test Depression Assessment Scale

Based on previous studies on the correlation between the tree drawing test and depression²⁴, the Tree Drawing Test Depression Assessment Scale (National Patent No.: 2023-A-000079360) was developed. This scale consists of 39 items, including overall information, crown features, trunk features, root features, ground line, non-theme information, and general information. The scale assigns scores based on the relevance of various indicators to depression, with scores ranging from 0 to 5, where the absence of an indicator scores 0, and some indicators are scored on a 1–5 scale. A cutoff score of 13 is used, where scores ≥ 13 indicate a tendency for depression.

DSM-5

The Diagnostic and Statistical Manual of Mental Disorders (DSM-5), published by the American Psychiatric Association (APA), is the most commonly used guide for diagnosing mental illnesses in the United States and other countries. The first edition was published in 1952, and the fifth edition was released on May 23, 2013²⁵.

Statistical methods

Statistical analysis was performed using SPSS 24.0 software. The validity indices included sensitivity, specificity, the area under the receiver operating characteristic curve (AUC), positive predictive value (PPV), and negative predictive value (NPV). Continuous data were analyzed using the mean \pm standard deviation ($x \pm s$) and t-tests, while categorical data were analyzed using frequency statistics and χ^2 tests. A p-value of < 0.05 was considered statistically significant.

Results

Participants

The study comprised 50 adolescent participants diagnosed with depression, ranging in age from 12 to 17 years, including 35 males and 15 females. Additionally, 54 normal controls of the same age range were recruited, consisting of 37 males and 17 females. The demographic characteristics of both groups are summarized in Table 1 and Fig. 1. Statistical analysis revealed no significant differences in gender and age distribution between the depressive and control groups ($P > 0.05$), indicating well-matched groups.

	Patients with depression (n = 50)	Normal control group (n = 54)	Test statistic	p-value
Total score (M/SD)	16.96(4.85)	7.26(3.44)	t = 11.831	<0.001
Assessment result			$\chi = 1$	<0.001
Tendency towards depression (≥ 13) (n/%)	40(80)	2(3.7)		
No tendency towards depression (≤ 13) (n/%)	10(20)	52(96.3)		

Table 2. Comparative analysis of intergroup differences in depression assessment.

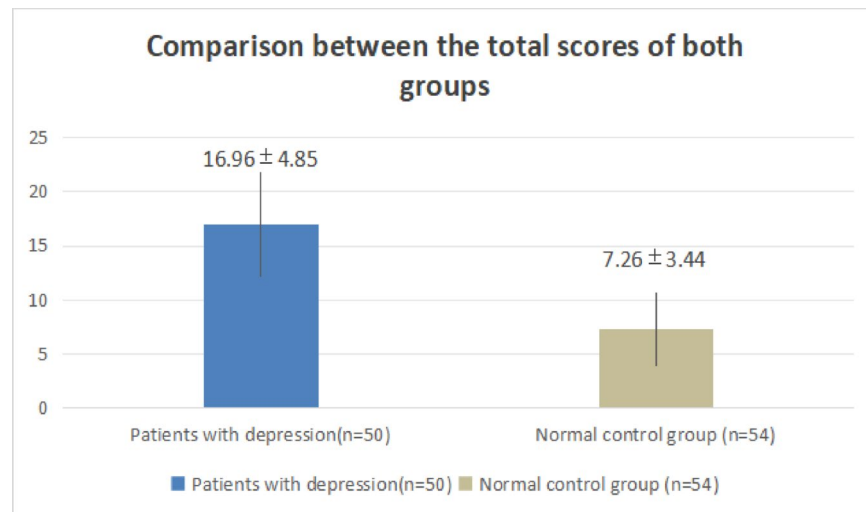


Fig. 2. Comparison between the total scores of both groups.

Effectiveness of the Tree Drawing Test Depression Assessment Scale in Screening for Depression

The total score for the depression group was 16.96 ± 4.85 , while the control group had a total score of 7.26 ± 3.44 . The t-value was 11.831, and the p-value was <0.001 , as detailed in Table 2 and Fig. 2. The cutoff point was determined using the maximum Youden Index to ensure the maximization of both sensitivity and specificity. A score of ≥ 13 was established as the cutoff point, with the following results: Youden Index = 0.761, sensitivity = 0.780, specificity = 0.981, positive predictive value (PPV) = 0.952, and negative predictive value (NPV) = 0.839 (see Table 3). The area under the receiver operating characteristic (ROC) curve was 0.951 (95% confidence interval: 0.913–0.989) (see Fig. 3). Drawings with scores close to 13 were re-assessed by different raters to determine the final score.

Rater reliability of the Tree Drawing Test Depression Assessment Scale

Prior to the formal study, three graduate students majoring in psychology were recruited and received one week of standardized training based on the scoring manual. The training included a detailed explanation of the scoring criteria for each item. Two raters were then randomly selected to independently score the tree drawings of 104 participants. Two raters independently scored the tree drawings of 104 participants. The raters were both graduate students in psychology, and they scored according to the assessment manual. The inter-rater reliability of the scores was evaluated by calculating Cohen's Kappa for the scores provided by the two raters. The results are shown in Table 4.

Discussion

The general data in this study show that there are more males than females in the adolescent depression group, which is inconsistent with the commonly observed male-to-female ratio in depression symptoms during adolescence in foreign studies. The gender differences in adolescent depression symptoms are not yet unified in domestic research²⁸, and the results of this study are consistent with some findings on gender ratios in China^{3,29}. The observed gender differences may be partly attributable to variations in gender-specific educational approaches in China. Within the context of traditional cultural expectations, males are often placed under greater academic and developmental pressure from an early age, as they are expected to achieve higher educational and career success. This increased burden may contribute to a higher risk of depressive disorders among male adolescents²⁸. Additionally, gender differences may also be related to variations in the expression of depressive symptoms, social cognitive biases, and help-seeking behaviors. These factors warrant further investigation in future research.

Different cutoff scores	Sensitivity	Specificity	Positive predictive value	negative predictive value
0	1.000	0.000	0.481	
1	1.000	0.056	0.495	1.000
2	1.000	0.111	0.510	1.000
3	1.000	0.148	0.521	1.000
4	1.000	0.185	0.532	1.000
5	1.000	0.296	0.568	1.000
6	0.980	0.463	0.628	0.962
7	0.980	0.537	0.662	0.967
8	0.980	0.648	0.721	0.972
9	0.980	0.704	0.754	0.974
10	0.900	0.815	0.818	0.898
11	0.840	0.889	0.875	0.857
12	0.800	0.944	0.930	0.836
13	0.780	0.981	0.974	0.828
14	0.660	0.981	0.970	0.757
15	0.640	0.981	0.969	0.746
16	0.440	1.000	1.000	0.659
17	0.400	1.000	1.000	0.643
18	0.380	1.000	1.000	0.635
19	0.300	1.000	1.000	0.607
20	0.280	1.000	1.000	0.600
21	0.240	1.000	1.000	0.587
22	0.160	1.000	1.000	0.562
23	0.120	1.000	1.000	0.551
24	0.040	1.000	1.000	0.529
25	0.020	1.000	1.000	0.524

Table 3. Evaluation results of different cutoff points for depression screening.

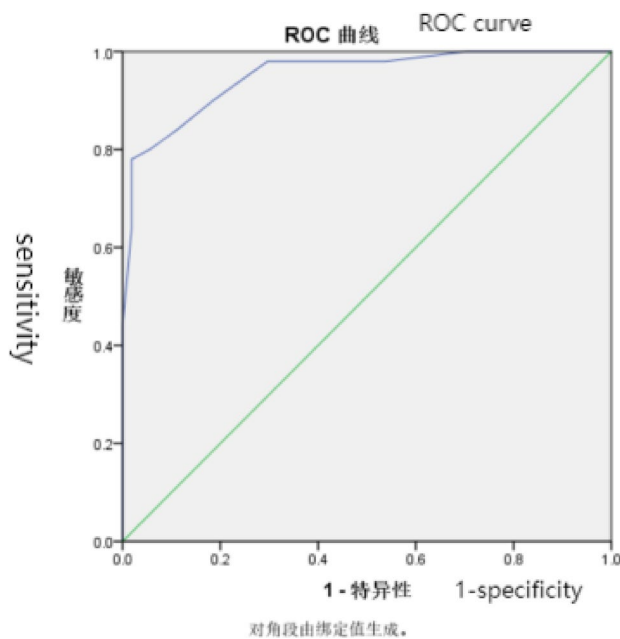


Fig. 3. ROC curve of the tree drawing projection test depression assessment form for screening for tendencies towards depression.

Item	Kappa	p
1	0.913	<0.001
2	0.865	<0.001
3	0.902	<0.001
4	0.907	<0.001
5	0.936	<0.001
6	0.895	<0.001
7	0.943	<0.001
8	0.906	<0.001
9	0.891	<0.001
10	0.926	<0.001
11	0.924	<0.001
12	0.884	<0.001
13	0.852	<0.001
14	0.932	<0.001
15	0.906	<0.001
16	0.925	<0.001
17	0.762	<0.001
18	0.771	<0.001
19	0.753	<0.001
20	0.977	<0.001
21	0.904	<0.001
22	0.843	<0.001
23	0.905	<0.001
24	0.971	<0.001
25	0.970	<0.001
26	0.852	<0.001
27	0.884	<0.001
28	0.812	<0.001
29	0.754	<0.001
30	0.821	<0.001
31	0.901	<0.001
32	0.797	<0.001
33	0.921	<0.001
34	0.923	<0.001
35	0.874	<0.001
36	0.921	<0.001
37	0.814	<0.001
38	0.931	<0.001
39	0.956	<0.001

Table 4. Rater Consistency Test.

This study aimed to evaluate the effectiveness of the Tree Drawing Test Depression Assessment Scale in screening for adolescent depressive disorders. By assessing 50 adolescents with depressive disorders and 54 healthy controls, the results indicate that the Tree Drawing Test Depression Assessment Scale has good effectiveness and high consistency in screening for adolescent depression.

First, the results show a statistically significant difference in total scores between the depression group and the control group ($p < 0.001$), indicating that the Tree Drawing Test can significantly distinguish between adolescents with and without depression. The mean total score for the depression group was 16.96 ± 4.85 , while the control group had a mean score of 7.26 ± 3.44 , showing a clear difference. This suggests that the Tree Drawing Test Depression Assessment Scale effectively reflects the level of depression in the adolescent population and provides valuable information for subsequent screening.

Additionally, through ROC curve analysis, the study determined 13 points as the cutoff score to maximize both sensitivity and specificity. At this cutoff, the Youden Index was 0.761, sensitivity was 0.780, specificity was 0.981, positive predictive value (PPV) was 0.952, and negative predictive value (NPV) was 0.839. The area under the ROC curve (AUC) was 0.951, with a 95% confidence interval of 0.913–0.989, indicating that the Tree Drawing Test Depression Assessment Scale has high diagnostic accuracy. An AUC value close to 1 shows excellent sensitivity and specificity of the tool for screening adolescent depression³⁰. Notably, the specificity

of 0.981 indicates that the tool has an extremely high accuracy in identifying individuals who do not have depression, effectively minimizing false positives.

In addition to its good validity, the rater consistency of the Tree Drawing Test Depression Assessment Scale was also validated. The Cohen's Kappa value ranged from 0.753 to 0.977, suggesting a high level of agreement between different raters. Rater consistency is an important factor in clinical screening tools, especially since evaluators may vary in clinical practice. Ensuring consistent evaluation results is crucial for the effectiveness of screening tools. This result shows that the Tree Drawing Test Depression Assessment Scale provides reliable and stable evaluation results between different raters, further enhancing its clinical value as a screening tool.

Compared to other existing depression screening tools, such as the BDI-II, RADS, and CES-D, the Tree Drawing Test Depression Assessment Scale demonstrated similarly high sensitivity and specificity in the adolescent population. Although each tool has its own characteristics, the high specificity and good consistency of this scale make it a recommended screening tool. When compared with the BDI-II and RADS, this assessment scale showed superior specificity while performing similarly in sensitivity. In comparison with the CES-D, the AUC value was significantly higher, further verifying the advantages of this tool³¹.

As shown in Table 4, sensitivity and specificity values fluctuated slightly between cutoff scores of 12 and 14. At a cutoff of 12, the sensitivity was 0.800 and specificity was 0.944; at 13, sensitivity slightly decreased to 0.780 while specificity increased to 0.981; at 14, sensitivity further declined to 0.660, with specificity remaining at 0.981. These findings suggest that although a cutoff score of 13 provides the statistically optimal balance between sensitivity and specificity, individuals scoring near this threshold may be at risk of misclassification, leading to either false positives or false negatives. Therefore, results around this margin should be interpreted with caution, and follow-up assessments or the use of additional evaluation tools may be recommended to improve diagnostic accuracy.

Despite the clinical relevance of the current findings, several limitations should be noted. First, the relatively small sample size may restrict the generalizability of the results. Second, all participants were recruited from a single hospital, resulting in a relatively homogeneous regional and cultural background that may not adequately represent the broader adolescent population, particularly those from diverse geographic or ethnic-cultural settings^{32,33}. Furthermore, the study did not explore the underlying mechanisms of gender differences or potential psychosocial contributing factors.

Future research should aim to include a larger and more diverse sample of adolescents from various regions, schools, and cultural backgrounds in order to validate the generalizability and cultural adaptability of the Tree Drawing Depression Assessment Scale. Additionally, integration with standardized clinical interviews (e.g., MINI-KID), self-report measures (e.g., BDI-II), and parent/teacher reports is recommended to establish a multi-informant screening framework, which may enhance both diagnostic precision and clinical utility.

In conclusion, the Tree Drawing Depression Assessment Scale demonstrated notable effectiveness in screening for depressive symptoms among adolescents, with high sensitivity, specificity, and inter-rater reliability. As a non-verbal, low-cost, and easy-to-administer tool, it offers unique advantages in adolescent populations, especially among those who struggle with verbal expression or exhibit emotional concealment. Nevertheless, to ensure comprehensive and accurate assessment, this tool is best utilized as an initial screening measure in conjunction with other clinical evaluation methods. In particular, integrating interview-based assessments, behavioral observations, and multi-source reporting into school mental health screening and early intervention efforts may further improve the sensitivity of depression detection and the timeliness of intervention.

Data availability

The dataset generated and analyzed in the current study can be obtained in an anonymized format from the corresponding author upon reasonable request.

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Author contributions

Each author made an indispensable contribution to this research paper. The specific contributions of each author are as follows: Guorui Liu collected data; Wei Liu wrote the paper; Jing Wen analyzed data; Yige Liu and Hui Jin searched for literature; Ziyang Li and Yanfei Zhang guided this research and reviewed the manuscript. Ziyang Li and Yanfei Zhang were the corresponding authors. Guorui Liu, Wei Liu and Jing Wen were the first co-authors.

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Declarations

Competing interests

The authors declare no competing interests.

Ethical approval

All participants were informed about the study process and possible risks. The study was approved by the Ethics Committee of Suzhou Guangji Hospital (Batch Number: 2021–012), all methods were performed in accordance with the relevant guidelines and regulations. Written informed consent had been obtained from the parents or legal guardians of all participants under the age of 16.

Additional information

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