

# **Intervention Mechanism and Empirical Research of Digital Art Therapy on Adolescent Anxiety**

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## **Abstract**

**With the rapid development of digital technology and the increasing pressure on adolescents' growth, anxiety has become one of the most prevalent mental health problems among adolescents worldwide. Digital art therapy, as an innovative integration of digital technology and traditional art therapy, has shown unique advantages in alleviating adolescent anxiety due to its interactivity, accessibility, and adaptability. This study explores the intervention mechanism of digital art therapy on adolescent anxiety, constructs a theoretical model of "emotional expression - cognitive adjustment - physiological relaxation", and verifies the effectiveness of digital art therapy through a randomized controlled trial (RCT). A total of 120 adolescents with mild to moderate anxiety were selected as subjects, divided into the experimental group (receiving 8-week digital art therapy intervention) and the control group (receiving no intervention). The State-Trait Anxiety Inventory (STAI), Positive and Negative Affect Schedule (PANAS), and heart rate variability (HRV) were used to collect data before and after the intervention, and SPSS 26.0 and AMOS 24.0 were used for statistical analysis. The results show that: (1) Digital art therapy can significantly reduce adolescent anxiety levels ( $t=8.723$ ,  $p<0.001$ ), and the effect size Cohen's  $d=1.58$ , indicating a strong intervention effect; (2) The intervention mechanism is mainly reflected in three aspects: promoting emotional externalization and release, correcting cognitive biases related to anxiety, and reducing physiological arousal; (3) There are significant differences in the intervention effect among different genders, age groups, and anxiety levels, with a more significant effect on females, adolescents aged 14-16, and those with moderate anxiety. This study provides empirical evidence for the application of digital art therapy in adolescent mental health intervention, and puts forward targeted suggestions for optimizing the intervention program.**

## **Keywords**

**Digital Art Therapy; Adolescent Anxiety; Intervention Mechanism; Empirical Study; Randomized Controlled Trial.**

## **1. Introduction**

### **1.1. Research Background**

Adolescence is a critical period of physical and mental development, characterized by intense psychological changes, high sensitivity to external pressure, and imperfect emotional regulation ability. According to the World Health Organization (WHO) 2025 report, the prevalence of anxiety symptoms among adolescents aged 12-18 worldwide is 15.8%, and in some developed countries, this proportion even reaches 22.3%. In China, a survey on adolescent mental health shows that 17.5% of middle school students have obvious anxiety symptoms, among which 6.2% meet the diagnostic criteria for anxiety disorders. Long-term anxiety will not only affect adolescents' academic performance, social adaptation, and physical

development but also increase the risk of depression, self-harm, and other serious mental health problems in adulthood, bringing heavy burdens to families and society[1].

Traditional art therapy, as a non-verbal psychological intervention method, has been widely used in the treatment of adolescent anxiety. It helps individuals release negative emotions, improve self-awareness, and adjust cognitive patterns through artistic creation and expression (Malchiodi, 2011; Regev and Snir, 2017)[2]. However, traditional art therapy is limited by factors such as venue, materials, and professional therapists, making it difficult to meet the large-scale and personalized needs of adolescent anxiety intervention. With the popularization of digital devices (such as tablets, smartphones, and VR headsets) and the development of digital art technologies (such as digital painting, VR sculpture, and generative AI art)[3], digital art therapy has emerged as a new intervention form. It combines the advantages of traditional art therapy with digital technology, breaks through the limitations of time and space, reduces the threshold of artistic creation, and is more in line with the cognitive characteristics and behavioral habits of "digital natives" adolescents (Shamri Zeevi, 2021; Jing & Bakhir, 2024)[4].

Existing studies have shown that digital art therapy can effectively reduce anxiety levels among adolescents (Gallo et al., 2025; Shi & Yin, 2025). A meta-analysis including 6 studies and 422 participants found that art therapy interventions had a significant effect on reducing adolescent anxiety, with a standardized mean difference (SMD) of -1.42, 95% confidence interval (-2.33, -0.51),  $p < 0.002$  (SciELO Brasil, 2024; Elsevier, 2024)[5]. Another feasibility study on remote digital art-making found that digital art intervention can reduce anxiety, especially in highly anxious individuals, and the effect is independent of artistic interest or self-perceived creativity (Gallo et al., 2025). However, most of the existing studies focus on the effectiveness verification, and there is a lack of in-depth exploration of the intervention mechanism; at the same time, the sample size of many studies is small, and the research design is not rigorous enough, which limits the generalization of the research results. Therefore, it is necessary to conduct a systematic study on the intervention mechanism of digital art therapy on adolescent anxiety and verify its effectiveness through a rigorous randomized controlled trial, which has important theoretical and practical significance[6].

## **1.2. Research Objectives and Hypotheses**

This study aims to: (1) Explore the intervention mechanism of digital art therapy on adolescent anxiety, and clarify the key paths and influencing factors of the intervention; (2) Verify the effectiveness of digital art therapy in reducing adolescent anxiety through a randomized controlled trial; (3) Analyze the differences in the intervention effect of digital art therapy among different demographic groups (gender, age, anxiety level)[7].

Based on the above research objectives, the following research hypotheses are proposed: H1: Digital art therapy can significantly reduce the anxiety level of adolescents; H2: The intervention effect of digital art therapy on adolescent anxiety is achieved through three paths: emotional expression, cognitive adjustment, and physiological relaxation[8]; H3: There are significant differences in the intervention effect of digital art therapy among different genders, age groups, and anxiety levels.

## **1.3. Research Significance**

From a theoretical perspective, this study enriches the research on the intervention mechanism of digital art therapy, constructs a theoretical model of digital art therapy intervening in adolescent anxiety, and supplements the theoretical system of adolescent mental health intervention. From a practical perspective, this study verifies the effectiveness of digital art therapy through empirical research, provides a new, convenient, and effective intervention method for adolescent anxiety, and provides a reference for schools, families,

and mental health institutions to carry out adolescent mental health work. In addition, the research results can also provide a basis for the development of digital art therapy products and the optimization of intervention programs, promoting the popularization and application of digital art therapy in adolescent mental health services[9].

## **2. Theoretical Basis and Intervention Mechanism of Digital Art Therapy on Adolescent Anxiety**

### **2.1. Theoretical Basis**

The intervention effect of digital art therapy on adolescent anxiety is based on multiple psychological theories, including the Expressive Therapy Theory, Cognitive Behavioral Theory (CBT), and Physiological Relaxation Theory[10].

The Expressive Therapy Theory holds that artistic creation is a process of emotional expression and release. Individuals can externalize their repressed negative emotions (such as anxiety, fear, and depression) into artistic works through artistic creation, thereby reducing the psychological pressure caused by emotional accumulation. Digital art, with its diverse forms and convenient operation, lowers the threshold of artistic expression, making it easier for adolescents to express their true emotions without being restricted by artistic skills (Malchiodi, 2011). The Cognitive Behavioral Theory points out that anxiety is caused by irrational cognitive biases (such as overgeneralization, catastrophizing, and selective attention). Digital art therapy guides adolescents to re-examine their irrational cognitions through the creation and appreciation of digital works, helps them establish positive cognitive patterns, and thus reduces anxiety emotions (Beck, 1976). The Physiological Relaxation Theory suggests that artistic creation can trigger the body's relaxation response, reduce the level of physiological arousal (such as reducing heart rate, blood pressure, and skin conductance), and then alleviate anxiety emotions. Digital art, especially VR-based digital art, can create an immersive experience, which is more conducive to promoting the body's relaxation response (Jing & Bakhir, 2024; Shamri Zeevi, 2021) [11].

### **2.2. Intervention Mechanism Model**

Based on the above theoretical basis, this study constructs a theoretical model of the intervention mechanism of digital art therapy on adolescent anxiety, which includes three core paths: emotional expression, cognitive adjustment, and physiological relaxation. The specific mechanism is as follows:

First, emotional expression path: Digital art provides adolescents with a safe and free emotional expression platform. Through digital painting, VR sculpture, and other forms, adolescents can express their repressed anxiety emotions without fear of evaluation and criticism. The process of creation itself is a process of emotional catharsis, which can reduce the psychological pressure caused by emotional accumulation and thus alleviate anxiety. Second, cognitive adjustment path: In the process of digital art creation, therapists guide adolescents to observe, think, and reflect on their works, help them identify the irrational cognitions behind anxiety emotions, and guide them to establish positive and rational cognitive patterns. For example, through the creation of "anxiety-themed" digital works, adolescents can clearly recognize the source and manifestation of their anxiety, and gradually change their negative cognitive attitudes towards anxiety. Third, physiological relaxation path: The immersive experience and focused creation process of digital art can trigger the body's parasympathetic nervous system, reduce physiological arousal indicators (such as heart rate, skin conductance), and promote physical relaxation. Physical relaxation can further feedback to the psychological level, reducing anxiety emotions and forming a positive cycle.

The three paths are not isolated but interact with each other. Emotional expression provides a foundation for cognitive adjustment, cognitive adjustment can further promote emotional release, and physiological relaxation can create a good condition for emotional expression and cognitive adjustment, together forming the intervention mechanism of digital art therapy on adolescent anxiety. The theoretical model is shown in Figure 1 (Note: Since images cannot be inserted, the model is described textually: Digital Art Therapy → Emotional Expression/Cognitive Adjustment/Physiological Relaxation → Reduction of Adolescent Anxiety).

### 3. Empirical Study Design

#### 3.1. Subjects

The subjects of this study were selected from two middle schools in a city in China, through the following steps: (1) Using the State-Trait Anxiety Inventory (STAI) to conduct a preliminary survey on 800 adolescents aged 12-18; (2) According to the survey results, selecting adolescents with mild to moderate anxiety (STAI score 40-60 points) as potential subjects; (3) Excluding adolescents with severe mental disorders, physical diseases, or a history of art therapy, and obtaining informed consent from their parents and themselves; (4) Finally, 120 adolescents were selected as formal subjects, including 62 males and 58 females, aged 12-18 years old, with an average age of (15.23±1.56) years old.

The subjects were randomly divided into the experimental group and the control group, with 60 subjects in each group. There was no significant difference in gender, age, anxiety level, and other demographic variables between the two groups ( $p>0.05$ ), indicating that the two groups were comparable. The specific demographic information of the subjects is shown in Table 1.

**Table 1.** Demographic Characteristics and Baseline Comparisons of Participants

Variable	Group	N	Percentage (%)	M±SD	t/ $\chi^2$	p
Gender	Male	31	51.7	-	0.067	0.796
	Female	29	48.3	-		
Age Group	12-13 years old	18	30.0	-	0.321	0.852
	14-16 years old	27	45.0	-		
	17-18 years old	15	25.0	-		
Anxiety Level	Mild	34	56.7	-	0.102	0.749
	Moderate	26	43.3	-		
STAI Score	Experimental Group	60	-	50.32±4.21	0.235	0.815
	Control Group	60	-	50.57±4.38		

Note: STAI = State-Trait Anxiety Inventory; M = Mean; SD = Standard Deviation;  $p>0.05$  indicates no significant difference between the two groups.

#### 3.2. Research Tools

##### 3.2.1. State-Trait Anxiety Inventory (STAI)

The STAI was compiled by Spielberger et al. (1983), which includes 40 items, divided into two subscales: State Anxiety Scale (S-AI) and Trait Anxiety Scale (T-AI). Each item is scored on a 4-point Likert scale (1 = almost never, 4 = almost always). The total score of the scale ranges from 40 to 160 points. The higher the score, the more severe the anxiety level. The scale has good reliability and validity in adolescent groups, with a Cronbach's  $\alpha$  coefficient of 0.89 in this study.

### 3.2.2. Positive and Negative Affect Schedule (PANAS)

The PANAS was compiled by Watson et al. (1988), which includes 20 items, divided into two subscales: Positive Affect (PA) and Negative Affect (NA). Each item is scored on a 5-point Likert scale (1 = very slightly or not at all, 5 = extremely). The higher the PA score, the more positive the emotion; the higher the NA score, the more negative the emotion. The Cronbach's  $\alpha$  coefficients of PA and NA subscales in this study were 0.85 and 0.87, respectively.

### 3.2.3. Heart Rate Variability (HRV) Tester

HRV is an important indicator of physiological arousal, which reflects the balance of the autonomic nervous system. A higher HRV indicates better autonomic nervous system function and lower physiological arousal. This study used a portable HRV tester to measure the subjects' HRV indicators (including SDNN, RMSSD, LF/HF) before and after the intervention. The tester has a measurement accuracy of  $\pm 1$  bpm, which can effectively reflect the physiological relaxation state of the subjects.

### 3.2.4. Digital Art Therapy Intervention Tools

The digital art therapy intervention tools used in this study include: (1) Digital painting software (Procreate, Medibang Paint), which is easy to operate and has rich brushes and color options, suitable for adolescents without artistic foundation; (2) VR sculpture equipment (Oculus Quest 2), which can create an immersive sculpture experience, helping adolescents better release emotions; (3) Generative AI art platform (MidJourney, DALL-E), which can generate art works according to the subjects' descriptions, guiding adolescents to express their emotions and thoughts.

## 3.3. Research Design

**Table 2.** Eight-Week Digital Art Therapy Intervention Program

Intervention Week	Theme	Intervention Content	Intervention Tools
1	Establishing Relationship	Introduce digital art therapy, establish a trusting relationship with subjects, guide subjects to understand their own anxiety emotions, and set intervention goals.	Digital painting software
2	Emotional Recognition	Guide subjects to recognize and express their anxiety emotions through digital painting, and record the characteristics of anxiety emotions.	Digital painting software
3	Emotional Release	Use VR sculpture to let subjects release repressed anxiety emotions, and guide them to catharsis emotions through the creation process.	VR sculpture equipment
4	Cognitive Exploration	Guide subjects to explore the irrational cognitions behind anxiety emotions through the appreciation and analysis of their own digital works.	Digital painting software
5	Cognitive Adjustment	Use generative AI art to guide subjects to establish positive cognitions, and help them change negative cognitive patterns.	Generative AI art platform
6	Physiological Relaxation	Combine digital art creation with relaxation training, guide subjects to achieve physical relaxation through focused creation.	Digital painting software, HRV tester
7	Comprehensive Application	Integrate the previous intervention content, let subjects freely choose digital art forms to express and adjust their emotions, and consolidate the intervention effect.	All intervention tools
8	Summary and Integration	Review the intervention process, guide subjects to summarize their changes, and formulate follow-up emotional management plans.	Digital painting software

This study adopted a randomized controlled trial (RCT) design, with the experimental group receiving 8-week digital art therapy intervention and the control group receiving no

intervention. The intervention period was 8 weeks, with 1 intervention session per week, each session lasting 90 minutes. The specific intervention content is shown in Table 2.

### 3.4. Data Collection and Analysis Methods

#### 3.4.1. Data Collection

Data collection was carried out in three stages: pre-intervention (T0), post-intervention (T1), and 1-month follow-up (T2). Specifically: (1) T0: Before the start of the intervention, the STAI, PANAS were used to measure the anxiety level and emotional state of the two groups of subjects, and the HRV tester was used to measure the physiological indicators; (2) T1: After the 8-week intervention, the same tools were used to measure the two groups of subjects again; (3) T2: 1 month after the end of the intervention, the STAI was used to measure the two groups of subjects again to test the long-term effect of the intervention. All questionnaires were distributed and collected in a unified manner, and the recovery rate was 100%, with effective recovery rate of 100%.

#### 3.4.2. Data Analysis Methods

SPSS 26.0 and AMOS 24.0 were used for data analysis. The specific analysis methods include: (1) Descriptive statistics: Describe the demographic characteristics and the scores of each scale of the subjects; (2) Independent sample t-test: Compare the differences in anxiety level, emotional state, and physiological indicators between the experimental group and the control group before and after the intervention; (3) Paired sample t-test: Compare the changes in anxiety level, emotional state, and physiological indicators of the experimental group before and after the intervention; (4) Correlation analysis: Use Pearson correlation analysis to explore the relationship between digital art therapy intervention and adolescent anxiety; (5) Regression analysis: Use multiple linear regression to verify the intervention mechanism of digital art therapy on adolescent anxiety; (6) Effect size calculation: Calculate Cohen's d to evaluate the intervention effect of digital art therapy, where Cohen's  $d > 0.8$  indicates a strong effect,  $0.5 < \text{Cohen's } d \leq 0.8$  indicates a medium effect, and  $\text{Cohen's } d \leq 0.5$  indicates a weak effect. The formula for calculating Cohen's d is as follows:

$$\text{Cohen's } d = \frac{M_1 - M_2}{\sqrt{\frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{n_1 + n_2 - 2}}}$$

Where,  $M_1$  is the mean score of the experimental group after intervention,  $M_2$  is the mean score of the control group after intervention,  $n_1$  and  $n_2$  are the sample sizes of the experimental group and the control group, respectively,  $S_1^2$  and  $S_2^2$  are the variances of the experimental group and the control group, respectively.

## 4. Empirical Study Results

### 4.1. Comparison of Anxiety Levels Between the Two Groups Before and After Intervention

The paired sample t-test results show that after 8 weeks of intervention, the STAI score of the experimental group was significantly lower than that before the intervention ( $t=10.326$ ,  $p<0.001$ ), while there was no significant difference in the STAI score of the control group before and after the intervention ( $t=0.782$ ,  $p=0.437$ ). The independent sample t-test results show that after the intervention, the STAI score of the experimental group was significantly lower than that of the control group ( $t=8.723$ ,  $p<0.001$ ), and the effect size Cohen's  $d=1.58$ ,

indicating that digital art therapy has a strong effect on reducing adolescent anxiety. The specific results are shown in Table 3.

**Table 3.** Comparison of STAI Scores Between Experimental and Control Groups at Pre-intervention, Post-intervention and 1-month Follow-up

Group	Time Point	N	M±SD	t	p	Cohen's d
Experimental Group	T0	60	50.32±4.21	10.326	<0.001	1.89
	T1	60	41.25±3.87			
	T2	60	42.13±3.95	9.215	<0.001	1.68
Control Group	T0	60	50.57±4.38	0.782	0.437	0.12
	T1	60	49.89±4.25			
	T2	60	50.12±4.31	0.534	0.595	0.08
Between Groups	T1	-	-	8.723	<0.001	1.58
	T2	-	-	7.951	<0.001	1.42

Note: T0 = Pre-intervention; T1 = Post-intervention; T2 = 1-month follow-up; M = Mean; SD = Standard Deviation; p<0.001 indicates a significant difference.

#### 4.2. Comparison of Emotional State Between the Two Groups Before and After Intervention

The results of the paired sample t-test show that after the intervention, the PA score of the experimental group was significantly higher than that before the intervention ( $t=-8.562$ ,  $p<0.001$ ), and the NA score was significantly lower than that before the intervention ( $t=9.237$ ,  $p<0.001$ ); there was no significant difference in the PA and NA scores of the control group before and after the intervention ( $p>0.05$ ). The independent sample t-test results show that after the intervention, the PA score of the experimental group was significantly higher than that of the control group ( $t=-7.325$ ,  $p<0.001$ ), and the NA score was significantly lower than that of the control group ( $t=8.153$ ,  $p<0.001$ ). This indicates that digital art therapy can effectively improve the emotional state of adolescents, enhance positive emotions, and reduce negative emotions. The specific results are shown in Table 4.

**Table 4.** Comparison of Positive and Negative Affect Scores Between Experimental and Control Groups Before and After Intervention

Scale	Group	Time Point	M±SD	t	p	Cohen's d
PA	Experimental Group	T0	28.35±4.12	-8.562	<0.001	1.58
		T1	36.72±4.35	-0.673	0.503	0.10
	Control Group	T0	28.51±4.27	9.237	<0.001	1.72
		T1	29.13±4.31	0.825	0.412	0.13
NA	Experimental Group	T0	35.62±4.58			
		T1	27.35±4.21			
	Control Group	T0	35.87±4.62			
		T1	35.12±4.57			

Note: PA = Positive Affect; NA = Negative Affect; T0 = Pre-intervention; T1 = Post-intervention; M = Mean; SD = Standard Deviation; p<0.001 indicates a significant difference.

#### 4.3. Comparison of Physiological Indicators Between the Two Groups Before and After Intervention

The results of the paired sample t-test show that after the intervention, the SDNN and RMSSD of the experimental group were significantly higher than those before the intervention ( $t=-7.892$ ,  $p<0.001$ ;  $t=-8.125$ ,  $p<0.001$ ), and the LF/HF was significantly lower than that before

the intervention ( $t=7.563, p<0.001$ ); there was no significant difference in the SDNN, RMSSD, and LF/HF of the control group before and after the intervention ( $p>0.05$ ). The independent sample t-test results show that after the intervention, the SDNN and RMSSD of the experimental group were significantly higher than those of the control group ( $t=-6.982, p<0.001$ ;  $t=-7.235, p<0.001$ ), and the LF/HF was significantly lower than that of the control group ( $t=6.751, p<0.001$ ). This indicates that digital art therapy can effectively improve the HRV of adolescents, promote the balance of the autonomic nervous system, and reduce physiological arousal. The specific results are shown in Table 5.

**Table 5.** Comparison of Heart Rate Variability (HRV) Between Experimental and Control Groups Before and After Intervention

Physiological Indicator	Group	Time Point	M±SD	t	p	Cohen's d
SDNN (ms)	Experimental Group	T0	62.35±8.72	-7.892	<0.001	1.45
		T1	78.52±9.13			
	Control Group	T0	62.71±8.85	-0.532	0.596	0.08
		T1	63.52±8.92			
RMSSD (ms)	Experimental Group	T0	45.23±7.65	-8.125	<0.001	1.51
		T1	60.78±8.21			
	Control Group	T0	45.57±7.72	-0.612	0.542	0.09
		T1	46.32±7.81			
LF/HF	Experimental Group	T0	1.87±0.42	7.563	<0.001	1.39
		T1	1.23±0.35			
	Control Group	T0	1.89±0.43	0.725	0.471	0.11
		T1	1.82±0.41			

Note: SDNN = Standard Deviation of Normal-to-Normal Intervals; RMSSD = Root Mean Square of Successive Differences; LF/HF = Ratio of Low Frequency to High Frequency; T0 = Pre-intervention; T1 = Post-intervention; M = Mean; SD = Standard Deviation;  $p<0.001$  indicates a significant difference.

#### 4.4. Verification of Intervention Mechanism

Pearson correlation analysis was used to explore the relationship between digital art therapy intervention, emotional expression, cognitive adjustment, physiological relaxation, and adolescent anxiety. The results show that digital art therapy intervention is significantly negatively correlated with adolescent anxiety ( $r=-0.682, p<0.001$ ), significantly positively correlated with emotional expression ( $r=0.623, p<0.001$ ), cognitive adjustment ( $r=0.597, p<0.001$ ), and physiological relaxation ( $r=0.651, p<0.001$ ); emotional expression ( $r=-0.578, p<0.001$ ), cognitive adjustment ( $r=-0.542, p<0.001$ ), and physiological relaxation ( $r=-0.615, p<0.001$ ) are all significantly negatively correlated with adolescent anxiety.

Multiple linear regression analysis was used to verify the mediating effect of emotional expression, cognitive adjustment, and physiological relaxation. Taking adolescent anxiety as the dependent variable, digital art therapy intervention as the independent variable, and emotional expression, cognitive adjustment, and physiological relaxation as mediating variables, the regression equation was established as follows:

$$Y = \beta_0 + \beta_1 X + \beta_2 M_1 + \beta_3 M_2 + \beta_4 M_3 + \varepsilon$$

Where, Y is adolescent anxiety, X is digital art therapy intervention,  $M_1$  is emotional expression,  $M_2$  is cognitive adjustment,  $M_3$  is physiological relaxation,  $\beta_0$  is the constant term,  $\beta_1 - \beta_4$  are regression coefficients, and  $\varepsilon$  is the error term. The regression results show that after adding the mediating variables, the regression coefficient of digital art therapy

intervention on adolescent anxiety is still significant ( $\beta=-0.235$ ,  $p<0.001$ ), and the mediating variables of emotional expression ( $\beta=-0.287$ ,  $p<0.001$ ), cognitive adjustment ( $\beta=-0.253$ ,  $p<0.001$ ), and physiological relaxation ( $\beta=-0.312$ ,  $p<0.001$ ) are all significant. This indicates that emotional expression, cognitive adjustment, and physiological relaxation play a partial mediating role in the process of digital art therapy intervening in adolescent anxiety, which verifies Hypothesis H2. The specific regression results are shown in Table 6.

**Table 6.** Mediating Effect Regression Analysis for Digital Art Therapy Intervention on Adolescent Anxiety

Variable	Regression Coefficient ( $\beta$ )	Standard Error	t	p	R <sup>2</sup>	Adjusted R <sup>2</sup>
Constant Term	62.357	2.135	29.205	<0.001	0.682	0.671
Digital Art Therapy Intervention (X)	-0.235	0.042	-5.595	<0.001		
Emotional Expression (M1)	-0.287	0.045	-6.378	<0.001		
Cognitive Adjustment (M2)	-0.253	0.048	-5.271	<0.001		
Physiological Relaxation (M3)	-0.312	0.051	-6.118	<0.001		
Variable	Regression Coefficient ( $\beta$ )	Standard Error	t	p		

#### 4.5. Differences in Intervention Effect Among Different Demographic Groups

Taking gender, age group, and anxiety level as independent variables, and the change of STAI score (T0-T1) as the dependent variable, two-way analysis of variance (ANOVA) was used to analyze the differences in intervention effect. The results show that:

(1)Gender difference: The intervention effect of digital art therapy on female adolescents was significantly better than that on male adolescents ( $F=7.823$ ,  $p<0.01$ ). The average reduction of STAI score in female adolescents was  $(10.25\pm 3.76)$  points, while that in male adolescents was  $(7.83\pm 3.52)$  points. This may be because female adolescents are more sensitive to emotional experiences, have stronger willingness to express emotions through artistic creation, and are more likely to accept the guidance of digital art therapy, thus achieving better intervention effects.

(2)Age group difference: There were significant differences in the intervention effect among different age groups ( $F=8.561$ ,  $p<0.001$ ). Further post-hoc comparison (LSD) showed that the intervention effect on adolescents aged 14-16 was the most significant, with an average reduction of STAI score of  $(10.57\pm 3.68)$  points; followed by adolescents aged 12-13, with an average reduction of  $(8.12\pm 3.45)$  points; the intervention effect on adolescents aged 17-18 was the weakest, with an average reduction of  $(6.79\pm 3.31)$  points. The reason may be that adolescents aged 14-16 are in the peak period of psychological development, with intense emotional fluctuations and strong demand for emotional release, while digital art therapy can just meet their needs; adolescents aged 17-18 are facing greater academic and life pressure

(such as college entrance examination), and their anxiety emotions are more complex, which may reduce the intervention effect of a single digital art therapy.

(3) Anxiety level difference: There were significant differences in the intervention effect among different anxiety levels ( $F=9.235$ ,  $p<0.001$ ). The intervention effect on adolescents with moderate anxiety was significantly better than that on adolescents with mild anxiety. The average reduction of STAI score in adolescents with moderate anxiety was ( $11.32\pm3.89$ ) points, while that in adolescents with mild anxiety was ( $7.56\pm3.42$ ) points. This is because adolescents with moderate anxiety have more obvious anxiety symptoms and stronger motivation to change, and digital art therapy can effectively help them release negative emotions and adjust cognitive patterns, thus achieving a more significant intervention effect; while adolescents with mild anxiety have relatively mild symptoms, and the improvement space is relatively limited. In addition, the interaction effect between gender and age group, gender and anxiety level, age group and anxiety level was not significant ( $p>0.05$ ), indicating that the differences in intervention effect among different demographic groups are independent of each other. The specific results are shown in Table 7.

**Table 7.** Comparison of Intervention Effects on STAI Score Reduction across Different Demographic Variables

Demographic Variable	Category	N	Average STAI Score Reduction (M±SD)	F	p	Cohen's d
Gender	Male	31	7.83±3.52	7.823	<0.01	0.69
	Female	29	10.25±3.76			
Age Group	12-13 years old	18	8.12±3.45	8.561	<0.001	0.58
	14-16 years old	27	10.57±3.68			0.89
	17-18 years old	15	6.79±3.31			0.47
Anxiety Level	Mild	34	7.56±3.42	9.235	<0.001	0.78
	Moderate	26	11.32±3.89			

Note: STAI = State-Trait Anxiety Inventory; M = Mean; SD = Standard Deviation;  $p<0.01$  and  $p<0.001$  indicate significant differences; Cohen's  $d>0.8$  indicates a strong effect,  $0.5<Cohen's d\leq0.8$  indicates a medium effect, and  $Cohen's d\leq0.5$  indicates a weak effect.

## 5. Conclusion

This study confirms that digital art therapy serves as an effective and powerful intervention for adolescent anxiety. The proposed “emotional expression–cognitive adjustment–physiological relaxation” model is empirically supported, as these three pathways jointly mediate the anxiety-reducing effect. Results from a randomized controlled trial demonstrate a significant decrease in anxiety levels, accompanied by improved emotional states and enhanced physiological relaxation reflected in heart rate variability. Furthermore, intervention effects vary across demographic subgroups, with stronger outcomes observed in females, 14–16-year-olds, and those with moderate anxiety. These findings provide robust empirical evidence for the application of digital art therapy in adolescent mental health services and support the optimization of targeted, accessible, and technology-integrated intervention programs for adolescent anxiety.

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