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Examining the Impact of Digital Therapy on Adolescent Emotional Disorders: A Meta-Analysis

Qimeng Kang[1], Huali Lin[2,*]

[1]Public Health School, Shaanxi University of Chinese Medicine, Xianyang 712046, Shaanxi, China
[2]Xi'an Mental Health Center, Xi'an 710000, Shaanxi, China
**Correspondence Author*

Abstract: ***Adolescent emotional disorders, particularly anxiety and depression, have emerged as significant concerns in global mental health. These disorders often affect adolescents' academic performance, social interactions, and overall well-being. Traditional face-to-face treatments face challenges in accessibility, compliance, and stigma. Digital psychotherapy, leveraging internet-based platforms and mobile applications, has become an increasingly popular alternative. This meta-analysis aims to evaluate the effectiveness of digital therapies in treating adolescent emotional disorders, specifically focusing on anxiety and depression. Results indicate that digital interventions are effective in reducing symptoms of both anxiety and depression in adolescents, with moderate-to-large effect sizes. The study further explores the role of intervention duration, personalization, and professional guidance in enhancing treatment outcomes. Findings suggest that longer interventions and those involving professional support are more effective. This meta-analysis provides robust evidence supporting digital psychotherapy as a valuable tool in addressing adolescent emotional disorders, offering flexible, accessible, and private treatment options, especially for those unable to access traditional face-to-face therapy.***

1. Introduction

Adolescent emotional disorders, particularly anxiety and depression, have become significant concerns in the global field of mental health. According to data from the World Health Organization, emotional disorders are among the most common mental health issues in adolescents, especially during the school-age and adolescent years. These disorders are often accompanied by declines in academic performance and difficulties in social interactions. Furthermore, adolescence is a critical period for emotional development and psychological well-being. If left untreated, emotional disorders may lead to long-term psychological distress, potentially impacting the individual's quality of life in adulthood [1]. In particular, disorders such as depression and anxiety not only affect emotional experiences but may also lead to physical symptoms, social withdrawal, and poor academic performance [2]. However, the application of traditional face-to-face psychotherapy faces several challenges within the adolescent population, including insufficient treatment resources, low patient adherence, and feelings of shame during the therapeutic process [3]. Consequently, there is an urgent need to identify convenient, effective, and accessible treatment methods to overcome these barriers.

Digital psychotherapy refers to mental health interventions delivered through digital platforms such as the internet, mobile devices, and virtual reality. It provides various therapeutic approaches, including cognitive behavioral therapy (CBT), exposure therapy, and relaxation techniques, via mobile apps and online platforms. Its primary advantages lie in flexibility, accessibility, and privacy protection [4]. Digital psychotherapy can facilitate personalized interventions, tailoring treatment to the specific symptoms and needs of the patient, thereby increasing treatment engagement [4].

In recent years, with the rapid development of digital technologies, digital psychotherapy has become an important tool for treating adolescent emotional disorders, particularly anxiety and depression. Research has shown that online cognitive behavioral therapy (CBT) is one of the most widely used and studied digital therapeutic approaches. This method, based on the core principles of CBT, helps patients identify and modify negative thinking patterns to alleviate symptoms of anxiety and depression. Studies indicate that online CBT provides adolescents with a flexible treatment option, enabling them to engage in therapy anytime and anywhere. This is particularly beneficial for those who face geographical barriers or social anxiety, making it difficult for them to participate in traditional face-to-face therapy [6]. Mewton et al. (2014) conducted a randomized controlled trial assessing the efficacy of online CBT for adolescent anxiety, finding that after 8 weeks of treatment, participants experienced significant symptom relief, with improvements sustained at follow-ups 3 and 6 months later. This suggests that online CBT not only offers a flexible and accessible treatment option for adolescents but also significantly reduces anxiety symptoms, making it particularly suitable for those who are unable to attend traditional therapy due to social shame or geographical limitations.

Additionally, [7] investigated the effectiveness of a self-guided digital intervention program, "moodGYM," for adolescent depression. The results showed that using this self-guided CBT program led to a significant reduction in depressive symptoms, and this effect was maintained for up to 3 months. This study suggests that self-guided interventions can effectively enhance adolescents' engagement in treatment while providing flexible and personalized treatment options. Moreover [8], evaluated the mobile app "Wysa," which also showed promising results in alleviating anxiety and depressive symptoms. This app uses artificial intelligence to offer emotional regulation and psychological support, emphasizing privacy protection, which further increases treatment adherence.

Virtual reality therapy, as an innovative treatment approach, has also demonstrated remarkable results. Research indicates that virtual reality can facilitate exposure therapy by simulating exposure scenarios, particularly showing efficacy

in the treatment of social anxiety and specific phobias [9]. Emmelkamp's study employed virtual reality exposure therapy to help adolescents confront social anxiety situations. The findings revealed that this therapy significantly reduced social anxiety symptoms, with treatment effects persisting at follow-up. Virtual reality provides adolescents with an immersive and highly interactive exposure experience, making therapy more engaging and enhancing patient involvement [10].

Furthermore, gamified therapy has garnered increasing attention as an emerging digital intervention. Amer et al. explored the impact of gamified therapy on adolescent emotional disorders, particularly in alleviating anxiety and depression. The study found that gamified therapy, through tasks and challenges, could stimulate adolescents' motivation for treatment, while interactivity and enjoyment improved their engagement and adherence. This suggests that gamified therapy not only offers effective emotional regulation strategies but also addresses the monotony often associated with traditional therapies [11].

The effectiveness of digital psychotherapy is also influenced by factors such as personalization and cultural adaptation. Gkintoni et al. found that online CBT, when combined with personalized treatment content and cultural adaptation, better meets the specific needs of adolescents, enhances treatment outcomes, and improves treatment acceptance [12]. In multicultural contexts, adapting treatment content to the life experiences of adolescents can help them better cope with emotional disorders, leading to better therapeutic results.

However, despite the promising potential of these digital therapeutic methods for adolescents, ensuring the personalization, interactivity, and professionalism of treatment content remains a key challenge in the design of digital interventions.

Meta-analysis, as a statistical method for integrating results from multiple independent studies, can effectively improve the robustness and precision of research conclusions. In this study, meta-analysis will help systematically assess the efficacy of different digital psychotherapy methods for adolescent emotional disorders and examine how various intervention variables, such as personalization, professional guidance, age, and gender, impact treatment outcomes. By synthesizing existing research findings, meta-analysis will address several critical questions:

Are there significant differences in the effects of digital psychotherapy for adolescent anxiety and depression across different intervention durations?

What are the efficacy differences among various forms of digital psychotherapy for treating adolescent anxiety and depression?

What is the role of personalized interventions? How does the level of personalization in treatment affect outcomes, and can personalized treatment improve treatment effectiveness and adherence?

How does professional support influence treatment outcomes? Does guidance from professionals increase treatment trust and efficacy?

Through answering these questions, the meta-analysis will provide more systematic and precise empirical evidence for the application of digital psychotherapy among adolescents and offer guidance for optimizing future interventions.

2. Methods

2.1 Research Design

Meta-analysis is a statistical method aimed at systematically synthesizing the results of multiple related studies to obtain an overall estimate of the effect of an intervention or treatment. Its core principle is that by combining effect sizes, it can address issues such as small sample sizes and large design heterogeneity in individual studies, thereby providing more reliable and generalizable conclusions [13].

In meta-analysis, effect size is a standardized measure of the magnitude of the intervention effect across different studies. Effect size allows the results of different studies to be unified on a common scale, making comparisons between studies more comparable [14]. The most commonly used effect size metrics include standardized mean difference (SMD), Hedges' g, and Cohen's d. Hedges' g quantifies the effect of an intervention by dividing the difference in means between the treatment and control groups by the standard deviation. It is more accurate than Cohen's d and SMD in small sample studies, as it corrects for sample bias, resulting in a more stable estimate of the effect size [15]. Therefore, Hedges' g will be used to assess the effect of digital psychotherapy on adolescent anxiety and depression. To facilitate the interpretation and practical significance of the effect size, the following criteria are typically used to judge the magnitude of the effect:

Small effect ($g = 0.2$): Indicates a small intervention effect. Although the intervention has had some impact in certain areas, its actual clinical significance is limited and may be insufficient to provoke a significant change in practice.

Medium effect ($g = 0.5$): Indicates a moderate effect. The intervention can somewhat improve adolescents' emotional states, and this effect holds practical clinical significance. Such an effect is typically seen as a visible positive impact of the treatment on emotional disorders.

Large effect ($g = 0.8$ or above): Indicates a significant effect. The intervention produces a noticeable alleviation of anxiety and depression symptoms. This effect generally means the intervention can have a profound impact on the adolescent population and is of high clinical and practical significance in improving emotional disorders.

Through this standardized effect size estimation, meta-analysis provides a clear and intuitive scale to help better understand the effectiveness of digital psychotherapy in alleviating adolescent emotional disorders.

Additionally, to reveal the impact of different moderating variables (such as intervention methods, degree of

personalization, and whether professional guidance is provided) on the intervention's effectiveness, this study will systematically screen and extract data from the existing literature to analyze the results.

2.2 Literature Search

The literature search for this study was conducted using a systematic approach to ensure the inclusion of all relevant studies. Initially, we selected several academic databases for the search, including PubMed, PsycINFO, and Web of Science. These databases span multiple fields and provide high-quality primary research. To ensure comprehensive coverage, a variety of keyword combinations were used, such as "digital psychotherapy," "e-therapy," "internet-based therapy," "online therapy," "digital intervention," "emotional disorders," "adolescent," "anxiety," and "depression." After an initial search, all potentially relevant studies were screened based on their titles and abstracts, with those that did not meet the inclusion criteria being excluded. Full-text reviews were then conducted to ensure that each study met the inclusion criteria, including the requirement that the study sample consisted of adolescents, the intervention was digital psychotherapy (such as online therapy or mobile applications), and pre- and post-intervention data on anxiety or depression levels were provided.

To further ensure the comprehensiveness of the literature, we conducted reference tracking by reviewing the reference lists of the included studies to identify potentially overlooked relevant studies. Throughout the screening process, all studies were independently reviewed by two researchers, with disagreements being resolved by a third-party researcher. Ultimately, studies that met stringent criteria were included, including those with experimental designs such as randomized controlled trials or other high-quality experimental methodologies, and those specifically related to digital interventions for adolescent anxiety or depression. This systematic literature search and selection process provided a solid foundation for the subsequent meta-analysis by ensuring the quality and relevance of the included studies.

2.3 Sample Selection Criteria

The inclusion criteria for the studies are as follows:

1) The study assessed the impact of digital psychotherapy on adolescent anxiety or depression.

2) The study must employ an experimental research design, excluding theoretical or review studies.

3) The study must report sample sizes, means, standard deviations, and other relevant statistical data for both experimental and control groups, including pre- and post-treatment changes in anxiety or depression levels.

4) The study population must consist of adolescents.

5) The intervention must involve internet-based, mobile app-based, computer-based, or other forms of digital psychotherapy.

Through the use of keyword searches and further refinement of the literature, the selection process is illustrated in Figure 1.

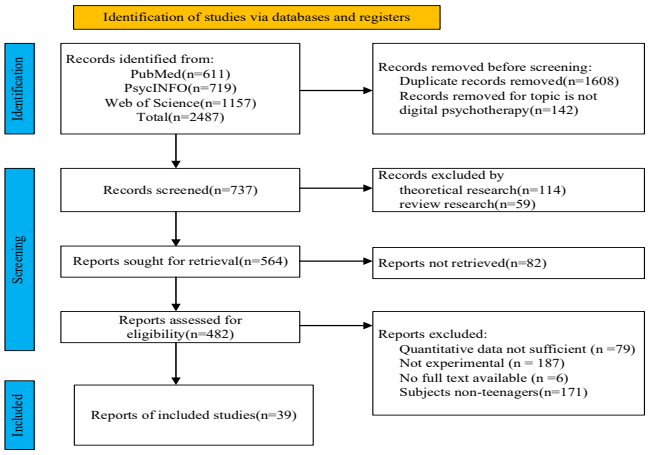

Figure 1: Literature screening process

Through a rigorous selection process, a total of 39 studies were included in the meta-analysis, yielding 54 independent effect sizes.

2.4 Data Processing and Coding

In the data extraction process, we extracted key information from each included study to ensure accurate analysis. First, we collected basic information about the study, including the authors, publication year, sample size, means, standard deviations of the experimental and control groups, etc., for comparison and categorization of different studies. Second, regarding the intervention characteristics, we extracted specific forms and details of each intervention. For example, interventions based on therapeutic methods were coded as 1, interventions focused on emotional and behavioral regulation were coded as 2, and interventions related to social support and situational interventions were coded as 3. The level of interaction in the intervention was coded as 1 if it involved professional guidance and as 2 if there was no professional guidance. The degree of personalization in the intervention was coded as 1 for standardized interventions and as 2 for personalized interventions. Additionally, we also extracted information on the duration of the interventions. All data extraction tasks were conducted by two independent researchers to ensure accuracy and consistency. In case of disagreements between the two researchers during data extraction, a third-party researcher was involved in making a final determination. This data extraction process provided a reliable foundation for the subsequent effect size calculations and subgroup analyses, ensuring the scientific rigor and replicability of all analytical results.

3. Results Analysis

3.1 Publication Bias Test

In meta-analyses, publication bias represents a major threat to the validity of synthesized findings, as studies with statistically significant or positive results are more likely to be published, whereas null or negative results may remain unpublished, potentially leading to inflated effect size estimates and reduced credibility of conclusions [16]. To ensure the robustness of the present findings regarding the

efficacy of digital psychological interventions for adolescent depression and anxiety, both graphical and statistical methods were employed to assess publication bias. Specifically, funnel plots were generated to visually inspect the distribution of individual study effects around the pooled estimate. In the absence of publication bias, the distribution of effect sizes is expected to be symmetrical within an inverted funnel shape [17]; substantial asymmetry may indicate the presence of bias. Additionally, Egger's regression test [18] was applied to statistically detect small-study effects, with $p<0.05$ indicating significant publication bias. In cases of asymmetry, the trim-and-fill method can be applied to impute potentially missing studies and adjust the pooled estimate [19]. In the current analysis, the funnel plot for depression outcomes appeared largely symmetrical, and Egger's test yielded $p = 0.263$; for anxiety outcomes, the funnel plot also showed no apparent asymmetry, and Egger's test yielded $p = 0.276$. Both results exceeded the 0.05 threshold, suggesting that no significant publication bias was present. Thus, the synthesized effect sizes are considered robust, lending credibility to the conclusions of this study.

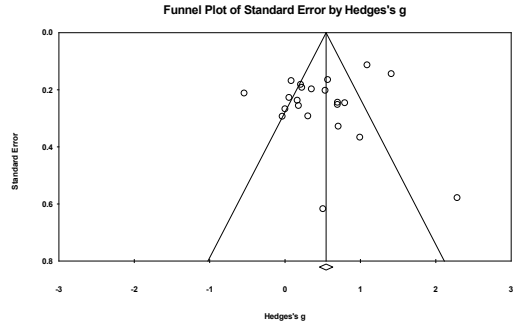

Figure 2: Funnel Plot of the Effect of Digital Psychotherapy on Adolescent Depression

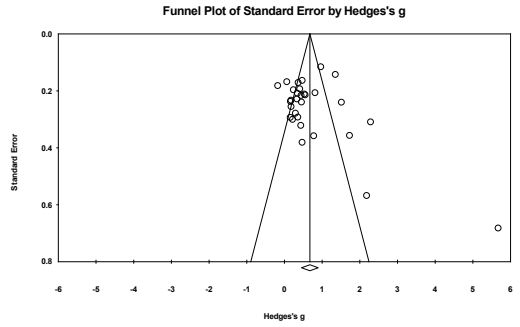

Figure 3: Funnel Plot of the Effect of Digital Psychotherapy on Adolescent Anxiety

3.2 Heterogeneity Test

In meta-analyses, assessing heterogeneity is essential because individual studies often differ in participant characteristics, intervention modalities, outcome measures, and follow-up durations, which may contribute to variability in effect sizes (Higgins et al., 2003). Substantial heterogeneity can compromise the validity of pooled estimates and thus requires careful evaluation to determine the appropriate statistical model and whether further subgroup or sensitivity analyses are warranted. Common indicators include Cochran's Q test and the I^2 statistic. The Q test examines whether the observed variance in effect sizes exceeds that expected by chance, with $p < 0.05$ suggesting significant heterogeneity. The I^2 statistic quantifies the proportion of variance attributable to heterogeneity rather than sampling error, with values of 25%, 50%, and 75% conventionally considered low, moderate, and high heterogeneity, respectively. In the present analysis, the effect of digital psychological interventions on adolescent depression yielded $Q = 211.258$, $df = 29$, $p < 0.001$, and $I^2 = 86.273\%$, while the effect on adolescent anxiety produced $Q = 130.886$, $df = 21$, $p < 0.001$, and $I^2 = 83.955\%$. Both results indicate a high degree of heterogeneity, suggesting that effect sizes varied substantially across studies. Accordingly, a random-effects model was applied for effect size synthesis, and further exploration of potential sources of heterogeneity is warranted.

Table 1: Heterogeneity Test Results

	Q	df	P	I^2
Digital Psychotherapy→Treatment Effect on Adolescent Depression	211.258	29	0.000	86.273
Digital Psychotherapy → Treatment Effect on Adolescent Anxiety	130.886	21	0.000	83.955

3.3 Main Effect Test

Given the substantial between-study variability identified earlier, a random-effects model was employed to synthesize the effect sizes across included studies, thereby providing a more robust overall estimate. Unlike the fixed-effects model, the random-effects model accounts for both within-study and between-study variance, making it particularly appropriate when variations exist in study design, sample characteristics, and intervention modalities.

Table 2: Main Effect Test Results

	Model	K	Hedges' g	95%CI		2-tailed	
				Lower limit	Upper limit	Z-value	P-value
Digital Psychotherapy → Treatment Effect on Adolescent Depression	Random	22	0.478	0.244	0.713	3.994	0.000
Digital Psychotherapy → Treatment Effect on Adolescent Anxiety	Random	30	0.683	0.460	0.905	6.025	0.000

For the interpretation of effect sizes, Hedges' g was selected as the standardized mean difference, as it provides a bias-corrected estimate that is especially suitable for studies with relatively small sample sizes. According to the conventional benchmarks proposed, values of approximately 0.2 indicate a small effect, around 0.5 a moderate effect, and 0.8 or higher a large effect [20]. This classification facilitates the evaluation of the clinical significance of intervention outcomes, beyond mere statistical significance.

The pooled results revealed that digital psychological interventions yielded a significant effect on adolescent depression, with Hedges' $g = 0.478$ (95% CI [0.244, 0.713], $Z = 3.994$, $p < 0.001$), corresponding to a moderate effect size. For adolescent anxiety, the combined effect was Hedges' $g = 0.683$ (95% CI [0.460, 0.905], $Z = 6.025$, $p < 0.001$), which falls within the range of a moderate-to-large effect. These findings indicate that digital interventions can produce clinically meaningful improvements in both depressive and anxious symptomatology among adolescents.

3.4 Moderating Effect Test

Although numerous studies have shown that digital psychotherapy has an overall positive effect on adolescent depression and anxiety, its efficacy is not consistent across all conditions. Variations in factors such as treatment duration, intervention type, degree of individualization, and professional involvement may influence the effectiveness and sustainability of the intervention. Therefore, it is necessary to explore which characteristics may enhance or weaken the intervention's effects through moderating effect analysis, thereby revealing the mechanisms of digital psychotherapy in different implementation contexts. Based on previous literature and research practice, this study selected four potential moderating variables: intervention duration, type of intervention, degree of individualization, and level of interactivity.

3.4.1 Intervention Duration

In this study, intervention duration was divided into three levels: short-term (≤6 weeks), medium-term (7–12 weeks), and long-term (>12 weeks). This classification method follows previous classifications of digital psychological interventions and cognitive behavioral therapy durations, where many studies divide interventions into short, medium, and long terms based on weeks in order to explore the dose-response relationship between treatment duration and effectiveness [21, 22]. Intervention duration is a significant factor affecting treatment outcomes. Short-term interventions may only alleviate symptoms, while medium- and long-term interventions are more likely to help patients maintain or further improve treatment effects. Therefore, this study conducts a moderating effect analysis on intervention duration to reveal differences in the treatment effects of adolescent emotional disorders across varying treatment durations.

3.4.2 Type of Intervention

Interventions are categorized into three types based on theory and implementation: therapeutic method-based interventions (e.g., iCBT, IPT), emotion and behavior regulation interventions, and social support and situational interventions. This classification aligns with common classifications of digital psychological intervention mechanisms in existing literature, distinguishing interventions based on whether they are theory-driven (therapy-based), focus on skills/emotion regulation, or center on social support/environmental changes [23, 24]. Different types of interventions may improve adolescent emotional distress through different mechanisms. Thus, this study examines the moderating effect of different intervention types on treatment outcomes.

Degree of Individualization of the Intervention: Based on whether the intervention content is customized to individual characteristics, this study categorizes interventions into "standardized" and "personalized." Personalized interventions, which match individual needs through modular selection, algorithm recommendations, or symptom assessments, are believed to improve adherence and effectiveness [25, 26]. Standardized interventions, on the other hand, follow fixed courses and content. Personalized interventions can more precisely address each adolescent's unique emotional distress and needs, potentially leading to better treatment outcomes. Therefore, this study analyzes the moderating effect of personalized versus standardized interventions in the treatment of adolescent depression.

Level of Interactivity in the Intervention: Based on the involvement of professional guidance, this study categorizes interventions as "professional guidance" or "self-help." In digital psychotherapy, professional involvement can enhance support and feedback, improving treatment outcomes. Especially in adolescent populations, professional guidance may help enhance treatment effects and adherence [27, 28]. Therefore, this study will explore the moderating effects of professional guidance versus self-help interventions on treatment outcomes.

Table 3: Subgroup Analysis Results of the Effect of Digital Psychotherapy on Adolescent Depression

Moderator	Subgroups	k	Hedges' g	95%CI		P-value	Test of Heterogeneity		
				Lower limit	Upper limit		Q-value	df(Q)	P-value
Intervention Duration	≤6 Weeks	6	0.205	0.028	0.381	0.023	4.969	2	0.083
	7 -12 Weeks	13	0.619	0.290	0.948	0.000			
	>12 Weeks	3	0.474	-0.243	1.192	0.195			
Intervention Measures	Therapy-based Interventions	15	0.387	0.094	0.680	0.010	1.62	2	0.445
	Emotion and Behavior Regulation Interventions	4	0.739	-0.008	1.486	0.053			
	Social Support and Situational Interventions	3	0.691	0.230	1.153	0.003			
Degree of Personalization of the Intervention	Standardized	14	0.491	0.153	0.829	0.004	0.006	1	0.941
	Personalized	8	0.473	0.140	0.806	0.005			
Interactivity of the Intervention	Professional Guidance	12	0.609	0.242	0.976	0.001	1.248	1	0.264
	Non Guidance	10	0.337	0.032	0.642	0.030			

This study conducted a moderating effect analysis on the treatment effect of digital psychotherapy on adolescent depression. The results are shown in Table 4. The impact of intervention duration was significantly different across groups. For short-term (≤6 weeks) interventions, the effect size was 0.205, with a P-value of 0.023, indicating a significant effect of short-term interventions on depression. For medium-term (7–12 weeks) interventions, the effect size was 0.619, with a P-value of 0.000, demonstrating a significant treatment effect. For long-term (>12 weeks) interventions, the effect size was 0.474, with a P-value of 0.195, which did not reach statistical significance. Heterogeneity analysis between groups showed a Q-value of 4.969, with a P-value of 0.083, suggesting some heterogeneity in the impact of intervention duration on treatment outcomes.

Furthermore, the treatment effects also varied under different intervention types. Therapy-based interventions (g = 0.387, P = 0.010) showed a significant treatment effect, while emotion and behavior regulation interventions (g = 0.739, P = 0.053), though showing a higher effect size, did not reach statistical significance. Social support and situational interventions (g = 0.691, P = 0.003) also showed a significant treatment effect. Heterogeneity analysis between groups showed a Q-value of 1.62, with a P-value of 0.445, indicating no significant difference in the effect of intervention type on treatment outcomes.

Next, personalized interventions had an effect size of 0.491, with a P-value of 0.004, while standardized interventions had an effect size of 0.473, with a P-value of 0.005. Both showed significant treatment effects. Heterogeneity analysis between groups showed a Q-value of 0.006, with a P-value of 0.941, suggesting that personalized interventions did not significantly outperform standardized interventions, possibly due to the limited number of studies and considerable differences in the forms of personalization.

Finally, the effect size of interventions with professional guidance was 0.609, with a P-value of 0.001, indicating that professional guidance significantly enhanced treatment effects. The effect size for self-help interventions was 0.337, with a P-value of 0.030, showing weaker effects. Heterogeneity analysis between groups showed a Q-value of 1.248, with a P-value of 0.264, suggesting no significant difference between the effects of professional guidance and self-help interventions.

Table 4: Subgroup Analysis Results of the Effect of Digital Psychotherapy on Adolescent Anxiety

Moderator	Subgroups	k	Hedges' g	95%CI		P-value	Test of Heterogeneity		
				Lower limit	Upper limit		Q-value	df(Q)	P-value
Intervention Duration	≤6 Weeks	7	0.219	0.055	0.383	0.009	15.095	2	0.001
	7 -12 Weeks	17	0.790	0.518	1.063	0.000			
	>12 Weeks	6	1.167	0.231	2.103	0.015			
Intervention Measures	Therapy-based Interventions	23	0.722	0.448	0.995	0.000	0.281	2	0.869
	Emotion and Behavior Regulation Interventions	4	0.644	-0.097	1.385	0.088			
	Social Support and Situational Interventions	3	0.583	0.137	1.028	0.010			
Degree of Personalization of the Intervention	Standardized	23	0.750	0.460	1.040	0.000	0.908	1	0.341
	Personalized	7	0.547	0.246	0.848	0.000			
Interactivity of the Intervention	Professional Guidance	21	0.852	0.531	1.174	0.000	4.907	1	0.027
	Non Guidance	9	0.402	0.166	0.638	0.001			

For the treatment of anxiety, this study also conducted a moderating effect analysis. As shown in Table 5, similar to the results for depression, intervention duration significantly influenced the treatment effect on anxiety. For short-term (≤6 weeks) interventions, the effect size was 0.219; for medium-term (7–12 weeks) interventions, the effect size was 0.790; and for long-term (>12 weeks) interventions, the effect size was 1.167, with effects increasing sequentially. The differences between groups were significant (Q = 15.095, p = 0.001).

For anxiety, the differences in intervention type were relatively small. Therapy-based interventions (g = 0.722) and social support interventions (g = 0.583) showed significant effects, while emotion regulation interventions did not reach statistical significance. Heterogeneity testing between groups did not show significant differences (Q = 0.281, p = 0.869).

Both personalized interventions (g = 0.547) and standardized interventions (g = 0.750) demonstrated significant therapeutic effects, but the difference between groups was not significant (Q = 0.908, p = 0.341).

Interventions with professional guidance showed significant effects on anxiety treatment (g = 0.852), while self-help interventions had an effect size of 0.402, showing weaker effects. The difference between groups was significant (Q = 4.907, p = 0.027).

4. Discussion

The Meta-analysis results of this study indicate that digital psychotherapy has a significant positive effect on both adolescent depression and anxiety, with the intervention effect on anxiety (Hedges' g = 0.683) being significantly better than that on depression (Hedges' g = 0.478). This result is consistent with previous studies, further validating the effectiveness of digital psychotherapy in adolescent emotional disorders [29]. Digital interventions provide a flexible and accessible alternative, overcoming the limitations of traditional face-to-face treatments in terms of time, space, and resources [30]. This is particularly significant for adolescents who cannot access traditional treatments due to social stigma, resource scarcity, or remote geographical locations.

4.1 Differences in Intervention Effects and Mechanisms

When analyzing the differences in intervention effects, subgroup analysis results revealed that intervention duration had a significant impact on efficacy. Specifically, medium-term (7-12 weeks) and long-term (>12 weeks) interventions were significantly more effective in alleviating anxiety and depression than short-term interventions. This finding aligns with the dose-response hypothesis, suggesting that longer treatments are more likely to consolidate cognitive and behavioral changes [22]. This may be because, in long-term interventions, adolescents have more time to

gradually establish more stable emotional regulation mechanisms, leading to deeper improvement in emotional symptoms. In contrast, short-term interventions may not provide adolescents with enough time to address deeper emotional distress or acquire effective coping strategies, leading to relatively weaker effects.

Additionally, comparisons of different intervention measures also revealed that digital interventions based on cognitive-behavioral therapy (CBT) showed more stable efficacy, while social support and situational interventions demonstrated positive effects in alleviating anxiety. This suggests that digital psychotherapy not only effectively replicates the core mechanisms of traditional cognitive-behavioral therapy (such as cognitive restructuring and exposure therapy), but also enhances adolescents' emotional regulation abilities by increasing social interaction and situational simulation. This is supported by existing research, which highlights that social support and situational interventions can significantly enhance adolescents' emotional stability and coping abilities [24].

4.2 The Role of Personalization and Professional Support

This study also explored the differences in efficacy between personalized and standardized interventions. Although both personalized and standardized interventions achieved good effects, no significant advantage was found for personalized interventions. This finding may be related to the inconsistency in the forms of personalized interventions in existing research. Specifically, personalized interventions involve various methods, such as algorithm recommendations and dynamic assessments, and the application of such technologies is not yet widespread [31]. Therefore, the effectiveness of personalized interventions may be limited by their operational feasibility and standardization. Future research could further improve the effectiveness of personalized interventions by establishing standardized intervention protocols and optimizing algorithmic recommendation systems.

At the same time, interventions with professional support showed significantly better effects than self-help interventions, which is consistent with previous studies [32]. Professionals, by providing real-time feedback, emotional support, and guidance, can help adolescents better cope with challenges during the treatment process, thus enhancing treatment adherence and trust. This finding suggests that in the future promotion of digital psychotherapy, it is important to increase the involvement of professionals to ensure the quality and effectiveness of interventions.

4.3 The Potential of Innovative Forms

With the development of technology, emerging interventions such as virtual reality therapy and gamified therapy have shown significant efficacy in some studies. In particular, in the treatment of anxiety disorders and social phobia, virtual reality creates an immersive environment that allows adolescents to confront and cope with anxiety-provoking situations more realistically, thus improving treatment effectiveness and engagement [33]. Gamified therapy, by increasing interactivity and fun, further enhances adolescents' engagement in treatment, boosting the sustainability and motivation for intervention. However, these technology-driven interventions still face challenges. First, virtual reality and gamified therapy are highly dependent on hardware, which may be difficult to implement in resource-poor areas. Second, cultural adaptation is an important issue, as adolescents from different regions may have different cultural backgrounds, emotional expressions, and ways of processing emotions. Therefore, when promoting these innovative interventions, factors such as technological accessibility, cultural adaptability, and social equity must be considered to avoid exacerbating the digital divide.

In conclusion, the results of this study demonstrate that digital psychotherapy has a strong empirical foundation for its application in adolescent emotional disorder interventions. Specifically, for public health and education systems, promoting digital psychotherapy can help alleviate the shortage of mental health service resources. However, the high heterogeneity of the research results also reminds us that the promotion of digital interventions should consider the individual differences, cultural backgrounds, and needs of different adolescent groups. For example, adolescents in different regions may have varying levels of acceptance of digital interventions, technological adaptability, and treatment expectations. Therefore, the implementation of digital interventions should take into account localized needs and cultural adaptation.

5. Conclusion

The Meta-analysis of this study shows that digital psychotherapy has a significant effect in alleviating adolescent depression and anxiety symptoms, with the intervention effect on anxiety being more pronounced. Factors such as intervention duration, type of intervention, and the presence of professional guidance all influence treatment outcomes. Medium-term and long-term interventions are more effective than short-term interventions, and professional guidance significantly enhances treatment effectiveness. Although both personalized and standardized interventions are effective, no significant advantage was found for personalized interventions in terms of efficacy.

Innovative virtual reality and gamified therapies have shown good potential, but still face challenges in practical application, including technological and cultural adaptation issues. Overall, digital psychotherapy provides a flexible and effective solution to address adolescent mental health issues. Future efforts should focus on further optimizing intervention methods, while considering individual differences and cultural backgrounds, to improve its application and effectiveness.

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