

Combined Effects of Aerobic Exercise and Group Behavioral Activation Therapy on Depressive Symptoms and Subjective Well-Being in Adolescents with Depression: A Randomized Controlled Trial

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Article Info	Abstract
Article type: Research Article Article history: Received 28 February 2026 Received in revised form 30 April 2026 Accepted 16 May 2026 Available online 29 June 2026 Keywords: Adolescent, Depression, Exercise, Behavior Therapy, Randomized Controlled Trial.	Introduction: Depression during adolescence represents a significant public health challenge that adversely affects psychosocial functioning and diminishes subjective well-being. Although aerobic exercise (AE) and group behavioral activation therapy (GBAT) have independently demonstrated effectiveness in reducing depressive symptoms, evidence regarding their combined effects remains limited. Objective: To examine the synergistic effects of AE and GBAT on depressive symptoms and subjective well-being among adolescents with depression. Method: A four-arm, parallel-group randomized controlled trial was conducted among 160 adolescents aged 13–17 years with elevated depressive symptoms in Tabriz, Iran. Participants were randomly assigned to AE (n=40), GBAT (n=40), combined intervention (n=40), or usual control (n=40). Interventions were delivered over 12 weeks. Beck Depression Inventory-II (BDI-II) and the KIDSCREEN questionnaire were used for measuring study variables at baseline, post-intervention, and 3-month follow-up. Data were analyzed using linear mixed-effects models. Results: Significant group × time interactions were observed for depressive symptoms ($F(6,288)=19.84$, $p<0.001$, $\eta^2=0.29$) and subjective well-being ($F(6,288)=22.41$, $p<0.001$, $\eta^2=0.32$). At follow-up, the combined intervention group demonstrated greater reductions in BDI-II scores (11.9 ± 4.4) compared with the AE (18.3 ± 5.0), GBAT (17.5 ± 4.7), and control groups (25.9 ± 5.6). Similarly, the combined intervention yielded the highest KIDSCREEN scores (66.1 ± 6.5) relative to AE (55.1 ± 7.2), GBAT (56.7 ± 6.8), and control (45.3 ± 7.5) groups (all $p<0.001$). Conclusions: Combination of AE and GBAT produced superior and sustained benefits, supporting the integration of exercise and behavioral interventions in adolescent mental health programs. Cite this Article: Salehian, MH. (2026). Combined Effects of Aerobic Exercise and Group Behavioral Activation Therapy on Depressive Symptoms and Subjective Well-Being in Adolescents with Depression: A Randomized Controlled Trial. <i>Physical Activity in Children</i>, 3(1), 99-107. https://doi.org/10.22034/pach.2026.588084.1095

1. Introduction

Adolescent depression is increasingly recognized as a critical global health issue because of its high prevalence and far-reaching consequences for young people (1). The disorder is typically manifested by persistent low mood, diminished interest in previously enjoyable activities, disturbances in cognition and sleep, and reduced daily functioning, all of which can adversely influence educational achievement, social interactions, and overall well-being (2,3). Adolescence represents a particularly vulnerable developmental stage, as profound biological maturation, psychological development, and social transitions may increase susceptibility to depressive symptoms (4). Current epidemiological evidence suggests that clinically meaningful depressive symptoms affect approximately one in every five to ten adolescents, with rates generally rising across the adolescent years (5,6). Beyond its immediate impact, depression during adolescence has been linked to a greater likelihood of substance use, self-injurious behaviors, suicidal

ideation and attempts, and the persistence or recurrence of depressive disorders later in life, highlighting the need for timely detection and evidence-based preventive and therapeutic strategies (7,8).

Beyond symptom reduction, contemporary mental health research increasingly emphasizes the importance of promoting positive psychological functioning. Subjective well-being is widely regarded as a fundamental dimension of adolescent mental health, reflecting both individuals' overall evaluations of their lives and the balance between positive and negative emotional experiences (9,10). Adolescents with depression often report diminished subjective well-being, lower life satisfaction, reduced positive affect, and impaired social functioning (11,12). While conventional treatments frequently focus on alleviating depressive symptoms, interventions that simultaneously enhance subjective well-being may contribute to more comprehensive and sustainable recovery outcomes. Therefore, identifying

interventions that effectively reduce depression while promoting positive mental health is essential.

Current treatment approaches for adolescent depression include pharmacotherapy, psychotherapy, or combinations of both (13,14). Although these interventions have demonstrated efficacy, several limitations remain. Antidepressant medications may be associated with adverse effects, concerns regarding long-term use, and inconsistent treatment adherence (15). Psychotherapeutic approaches, while effective, often require specialized professionals, considerable financial resources, and sustained engagement, which may limit accessibility for many adolescents (16). Furthermore, stigma related to mental health treatment may discourage adolescents from seeking or maintaining traditional forms of care (17). Accordingly, increasing attention has been directed toward affordable, practical, and non-pharmacological approaches that may serve as effective adjuncts to conventional treatment strategies.

Aerobic exercise (AE) has received considerable attention as a promising intervention for improving adolescent mental health (18-20). Regular participation in AE has been associated with significant reductions in depressive symptoms and improvements in psychological well-being (21-23). The beneficial effects of AE are thought to arise from multiple physiological pathways, including increased secretion of endorphins, modulation of serotonin and dopamine activity, attenuation of systemic inflammation, improvements in sleep, and stimulation of neuroplastic processes mediated by brain-derived neurotrophic factor (24,25). In addition to these physiological effects, exercise may foster psychological benefits by enhancing self-efficacy, providing opportunities for social interaction, improving body image, and promoting a sense of mastery and achievement (26-28).

Group behavioral activation therapy (GBAT) is another evidence-based intervention that has demonstrated effectiveness in treating depression (29,30). Rooted in behavioral learning theory and reinforcement models of depression, GBAT aims to increase engagement in meaningful, rewarding, and value-consistent activities while reducing patterns of avoidance and withdrawal that maintain depressive symptoms. According to behavioral activation theory, depression is perpetuated when individuals experience reduced contact with positive reinforcement and increasing behavioral avoidance. By systematically increasing participation in rewarding activities, GBAT restores environmental reinforcement and promotes adaptive emotional and behavioral functioning. GBAT offers additional advantages, including peer support, normalization of experiences, and cost-effectiveness (31). For adolescents, who are particularly sensitive to social contexts and peer relationships, GBAT may enhance motivation, social connectedness, and treatment adherence. Emerging evidence suggests that GBAT can alleviate depressive symptoms and enhance functioning among adolescents, with outcomes comparable to more intensive cognitive-behavioral approaches.

Although AE and GBAT share common therapeutic elements, they may influence depression through distinct yet complementary pathways. Both interventions encourage active engagement, increase

exposure to rewarding experiences, and counteract behavioral avoidance. However, AE primarily targets physiological and psychosocial mechanisms, whereas GBAT focuses on modifying maladaptive behavioral patterns and increasing participation in meaningful activities. Integrating these approaches may therefore produce synergistic effects that exceed the benefits of either intervention alone.

The theoretical rationale for combining AE with GBAT can also be explained through motivational and self-determination perspectives. Exercise provides repeated opportunities for mastery experiences, competence development, and social interaction, all of which may enhance intrinsic motivation for continued engagement in health-promoting behaviors (32). Conversely, GBAT equips adolescents with practical skills for identifying personal values, setting achievable goals, scheduling rewarding activities, and overcoming behavioral barriers that frequently limit participation in exercise (33). Consequently, each intervention may reinforce the effectiveness of the other, creating a reciprocal cycle in which increased behavioral engagement improves mood, while improved mood further strengthens motivation for sustained activity and treatment adherence.

Although AE and GBAT have each demonstrated beneficial effects on adolescent depression, evidence evaluating their combined application remains limited. Most previous studies have examined these interventions separately, leaving it unclear whether integrating physiological and behavioral approaches provides additional therapeutic benefits. Moreover, few randomized controlled trials have simultaneously assessed reductions in depressive symptoms alongside improvements in subjective well-being, despite growing recognition that positive mental health extends beyond symptom remission. Addressing this gap is particularly important during adolescence, a developmental stage in which effective interventions may have long-term implications for mental health. Consequently, scalable, school- and community-based programs that combine structured exercise with evidence-based psychological strategies may represent a practical approach to improving treatment accessibility and engagement. Therefore, the present randomized controlled trial compared the effects of AE, GBAT, and their combination on depressive symptoms and subjective well-being in adolescents with depression. It was hypothesized that all intervention groups would demonstrate improvements in both outcomes, with the combined intervention producing the greatest benefits because of the complementary physiological and behavioral mechanisms targeted by the integrated approach.

2. Methods

2.1. Study Design

This study employed a four-arm, parallel-group randomized controlled trial design.

2.2. Setting and Participants

This randomized controlled trial was conducted between June and December 2025 in secondary schools and affiliated adolescent mental health counseling centers in Tabriz, Iran. Participants were adolescents aged 13-17 years who screened positive for depressive

symptoms. Eligibility criteria included enrollment in a participating secondary school, a Beck Depression Inventory-II (BDI-II) score indicating mild-to-severe depressive symptoms, medical clearance to participate in moderate-intensity AE, the ability to complete the study assessments independently, and provision of written assent together with parental or legal guardian consent. Exclusion criteria comprised severe psychiatric disorders requiring immediate specialist treatment, medical conditions contraindicating AE participation, concurrent structured psychotherapy for depression, initiation or modification of antidepressant medication within the previous eight weeks, cognitive or developmental impairments limiting participation in group sessions, or an anticipated inability to comply with the intervention protocol or follow-up assessments.

Participants were recruited through school announcements, informational meetings, and referrals from school counselors and mental health professionals. Adolescents and their parents received detailed information regarding the study procedures before completing the BDI-II screening. Those meeting the initial eligibility criteria subsequently underwent a brief clinical interview conducted by a trained mental health professional to confirm study eligibility and verify the exclusion criteria.

The required sample size was estimated a priori using G*Power (Version 3.1) for a repeated-measures ANOVA examining the group $\times$ time interaction. Assuming a moderate effect size ($f = 0.25$), a significance level of .05, statistical power of 80%, four intervention groups, three assessment occasions, a correlation of .50 among repeated measurements, and a nonsphericity correction (ϵ) of 1.0, the minimum required sample size was calculated to be 128 participants. To accommodate an anticipated attrition rate of approximately 20%, the recruitment target was increased to 160 participants (40 participants per group).

Following completion of baseline assessments, participants were randomly allocated to one of the four study groups using a computer-generated randomization sequence prepared by an independent biostatistician who was not involved in recruitment, intervention delivery, outcome assessment, or data analysis. Variable block sizes of four and eight were used to maintain balanced group allocation throughout enrollment. Participant eligibility and informed consent procedures were completed by a research coordinator, whereas treatment allocation was implemented by a separate research assistant. Allocation concealment was ensured through the use of sequentially numbered, opaque, sealed envelopes that were opened only after baseline assessments had been completed.

Because of the nature of the interventions, neither participants nor intervention providers could be blinded to treatment assignment. Nevertheless, all outcome assessments were performed by trained assessors who remained unaware of group allocation. Data management and statistical analyses were conducted using anonymized participant identification codes, thereby maintaining analyst blinding until completion of the primary analyses. Participants were also instructed not to disclose their assigned intervention during follow-up assessments.

No episodes of inadvertent unblinding were reported during the trial.

2.3. Interventions

All interventions were delivered over a 12-week period.

2.3.1. Aerobic Exercise Group

Participants assigned to the AE group attended supervised exercise sessions three times per week for 12 weeks. Each session lasted approximately 60 minutes and was led by a certified exercise specialist. The exercise protocol followed the FITT principles. Sessions consisted of a 10-minute warm-up, 40 minutes of AE, and a 10-minute cool-down. AE included brisk walking, jogging, aerobic dance, circuit training, and group fitness exercises. Exercise intensity was maintained at 60–75% of age-predicted maximum heart rate and monitored using heart-rate monitors and the Borg Rating of Perceived Exertion scale. Intervention fidelity was monitored throughout the study. Exercise specialists completed standardized training before participant enrollment and followed a detailed intervention manual. Heart-rate data were reviewed during every session to verify that participants exercised within the prescribed intensity range, and attendance was recorded electronically. Participants attending at least 80% of scheduled exercise sessions were considered adherent to the intervention protocol. Periodic supervision by the principal investigator ensured protocol consistency across instructors.

2.3.2. Group Behavioral Activation Therapy Group

The GBAT intervention comprised twelve weekly group sessions, each lasting approximately 90 minutes and involving 8–10 adolescents. All sessions were delivered by a licensed clinical psychologist with specialized training in behavioral activation and adolescent mental health. The intervention was designed to foster psychological and behavioral change through a structured framework, including psychoeducation on depression and behavioral activation principles, the identification of personal values, and rigorous activity and mood monitoring. Participants were guided in scheduling mastery-oriented and pleasurable activities, developing adaptive problem-solving and goal-setting skills, identifying and reducing maladaptive avoidance behaviors, and building coping mechanisms for relapse prevention. To ensure the generalization of these skills into daily life, participants were required to complete weekly homework assignments and maintain detailed activity logs throughout the 12-week program. Treatment fidelity was enhanced through the use of a standardized therapist manual and structured session checklists. Therapists participated in regular supervision meetings with an experienced clinical psychologist throughout the intervention period to review treatment delivery and ensure adherence to behavioral activation principles. Homework completion and activity logs were reviewed during each session to monitor participant engagement and protocol adherence.

2.3.3. Combined Intervention Group

Participants in the combined group received both the AE and GBAT concurrently over the 12-week period. They attended three weekly AE sessions and one weekly GBAT session. GBAT was used to support exercise adherence by helping participants identify personal motivations, set activity goals, and address barriers to

participation. The combined intervention was designed to leverage the complementary physiological, psychological, and behavioral mechanisms of both approaches. Intervention fidelity procedures implemented in the individual interventions were maintained throughout the combined program to ensure consistent delivery of both treatment components.

2.3.4. Usual Care Control Group

Participants assigned to the control group continued to receive usual care available through their schools or healthcare providers. Usual care included access to school counseling services, educational resources, and referrals to mental health services when needed. No structured AE or GBAT were provided during the intervention period. Upon completion of the trial, participants in the control group were given access to the intervention materials.

2.4. Measurements

2.4.1. Depressive Symptoms

Depressive symptom severity was evaluated using the BDI-II. It has 21 items and responses are rated on a four-point scale (0–3), producing a cumulative score ranging from 0 to 63, with higher values reflecting more severe depressive symptoms. The Persian adaptation of the BDI-II has been psychometrically evaluated and shown to possess acceptable reliability and validity for use with Iranian adolescents.

2.4.2. Subjective Well-Being

Subjective well-being was measured using the 27-item KIDSCREEN questionnaire. Each item was rated on a 5-point Likert scale. Item scores are summed and transformed, with higher scores indicating more favorable levels of subjective well-being. The Persian version of the KIDSCREEN has demonstrated satisfactory reliability and validity in studies involving Iranian adolescents.

2.5. Data Collection Procedures

Outcome assessments were conducted at baseline (T0), immediately following the intervention period (T1), and at the 3-month follow-up (T2) by trained assessors blinded to group allocation. Sociodemographic information, including age, sex, educational level, family socioeconomic status, and relevant medical history, was collected at baseline. Intervention adherence was monitored through attendance records and participant logs. Adverse events related to the interventions were documented throughout the study.

Attendance rates for AE and GBAT sessions were calculated as the proportion of completed sessions relative to the total number of scheduled sessions. Participant engagement with homework assignments and activity logs was also documented.

2.6. Statistical Analysis

All analyses were performed using IBM SPSS Statistics version 29 following the intention-to-treat principle. Descriptive statistics were computed for all study variables, while baseline comparability among groups was assessed using one-way ANOVA for continuous variables and chi-square tests for categorical variables. Intervention effects on depressive symptoms and subjective well-being across the three assessment time points were examined using linear mixed-effects models estimated with restricted maximum likelihood (REML). The models included fixed effects for group, time, and the group $\times$ time interaction, together with participant-specific random intercepts to account for repeated measurements. Where significant interaction effects were detected, Bonferroni-adjusted post hoc comparisons were performed. Adjusted mean differences with 95% confidence intervals and Cohen's d were reported to quantify intervention effects. Missing outcome data were handled using full-information maximum likelihood estimation within the mixed-effects modeling framework under the assumption of missing at random. Statistical significance was set at $p < .05$.

3. Results

3.1. Participant Flow and Retention

Participant flow throughout the trial is presented in [Figure 1](#). Among the 247 adolescents screened for eligibility, 175 satisfied the inclusion criteria, and 160 provided informed consent and completed the baseline assessment. Participants were subsequently randomized in equal numbers to the AE, GBAT, combined intervention, or usual care control groups ($n = 40$ per group). During the study, 12 participants withdrew because of scheduling conflicts, relocation, loss to follow-up, or withdrawal of consent. Consequently, outcome data were available for 151 participants at the post-intervention assessment (94.4%) and 148 participants at the 3-month follow-up (92.5%). Consistent with the intention-to-treat approach, all available observations were retained in the analyses using linear mixed-effects models with maximum likelihood estimation.

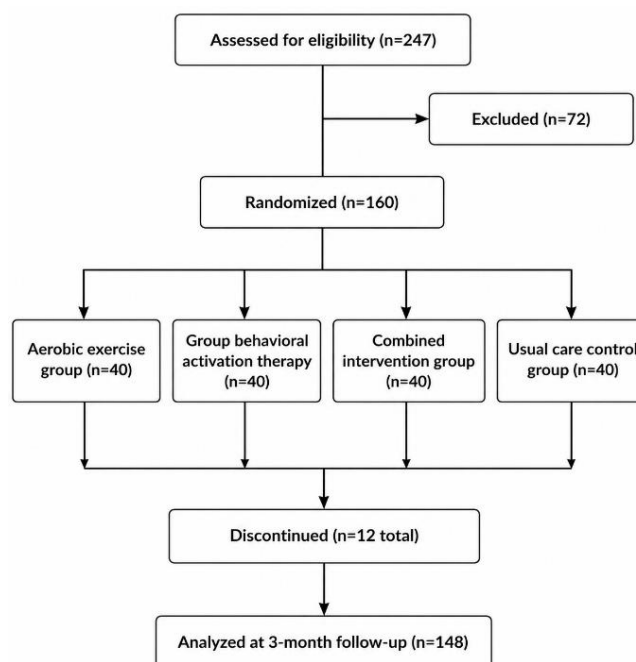


Figure 1. The CONSORT Flow Diagram of the Study.

3.2. Baseline Characteristics

No significant differences were observed among the four groups regarding demographic characteristics or

baseline outcome measures (all $p > 0.05$), indicating successful randomization.

Table 1. Baseline Demographic and Clinical Characteristics of Participants.

Variable	Aerobic Exercise	Behavioral Activation	Combined Intervention	Control	p
Age (years), Mean $\pm$ SD	15.1 $\pm$ 1.3	15.0 $\pm$ 1.2	15.2 $\pm$ 1.4	15.1 $\pm$ 1.3	0.88
Female, n (%)	23 (57.5)	22 (55.0)	24 (60.0)	21 (52.5)	0.93
Male, n (%)	17 (42.5)	18 (45.0)	16 (40.0)	19 (47.5)	0.93
BDI-II Score, Mean $\pm$ SD	28.6 $\pm$ 6.1	29.1 $\pm$ 5.9	28.8 $\pm$ 6.3	28.9 $\pm$ 6.0	0.97
KIDSCREEN Score, Mean $\pm$ SD	42.7 $\pm$ 8.3	43.1 $\pm$ 7.9	42.4 $\pm$ 8.5	42.8 $\pm$ 8.1	0.96

3.3. Intervention Adherence

Mean attendance rates were 85.4% (95% CI: 82.1–88.7%) for the AE group, 87.8% (95% CI: 84.9–90.7%) for the GBAT, and 83.9% (95% CI: 80.4–87.4%) for the combined intervention group. Overall adherence exceeded the predefined 80% attendance criterion in all intervention groups, indicating satisfactory intervention fidelity. Exercise intensity targets were successfully maintained throughout the intervention, with heart-rate monitoring confirming that participants exercised within the prescribed moderate-intensity range during supervised sessions. Therapists also completed structured fidelity checklists during GBAT sessions, and no major protocol deviations were identified. No

serious adverse events related to the interventions were reported.

3.4. Effects on Depressive Symptoms

Significant main effects were observed for time ($F(2,288)=94.72$, $p<0.001$, $\eta^2=.40$), group ($F(3,144)=28.65$, $p<0.001$, $\eta^2=.37$) and group $\times$ time interaction ($F(6,288)=19.84$, $p<0.001$, $\eta^2=.29$). Bonferroni-adjusted post hoc analyses demonstrated significantly greater reductions in depressive symptoms for all intervention groups compared with the control group at both post-intervention and the 3-month follow-up (all $p < 0.001$). The combined intervention produced the largest improvement, outperforming both the AE and GBAT groups (Table 2).

Table 2. Changes in Depressive Symptoms (Bdi-II Scores) across Study Groups.

Time Point	Aerobic Exercise	Behavioral Activation	Combined Intervention	Control
Baseline (T0)	28.6 $\pm$ 6.1	29.1 $\pm$ 5.9	28.8 $\pm$ 6.3	28.9 $\pm$ 6.0
Post-Intervention (T1)	19.8 $\pm$ 5.4	18.9 $\pm$ 5.1	13.4 $\pm$ 4.8	26.7 $\pm$ 5.8
3-Month Follow-up (T2)	18.3 $\pm$ 5.0	17.5 $\pm$ 4.7	11.9 $\pm$ 4.4	25.9 $\pm$ 5.6

3.5. Effects on Subjective Well-Being

Significant effects were observed for time ($F(2,288)=81.56$, $p<0.001$, $\eta^2=.36$), group ($F(3,144)=31.27$, $p<0.001$, $\eta^2=.39$) and the group $\times$ time interaction ($F(6,288)=22.41$, $p<0.001$, $\eta^2=.32$). Bonferroni-adjusted post hoc analyses demonstrated significantly greater

improvements in subjective well-being for all intervention groups compared with the control group at both post-intervention and the 3-month follow-up (all $p < 0.001$). The combined intervention produced the greatest improvement, outperforming both the AE and GBAT groups (Table 3).

Table 3. Changes in Subjective Well-Being (KIDSCREEN Scores) across Study Groups.

Time Point	Aerobic Exercise	Behavioral Activation	Combined Intervention	Control
Baseline (T0)	42.7 ± 8.3	43.1 ± 7.9	42.4 ± 8.5	42.8 ± 8.1
Post-Intervention (T1)	53.6 ± 7.4	55.2 ± 7.1	63.8 ± 6.9	44.5 ± 7.8
3-Month Follow-up (T2)	55.1 ± 7.2	56.7 ± 6.8	66.1 ± 6.5	45.3 ± 7.5

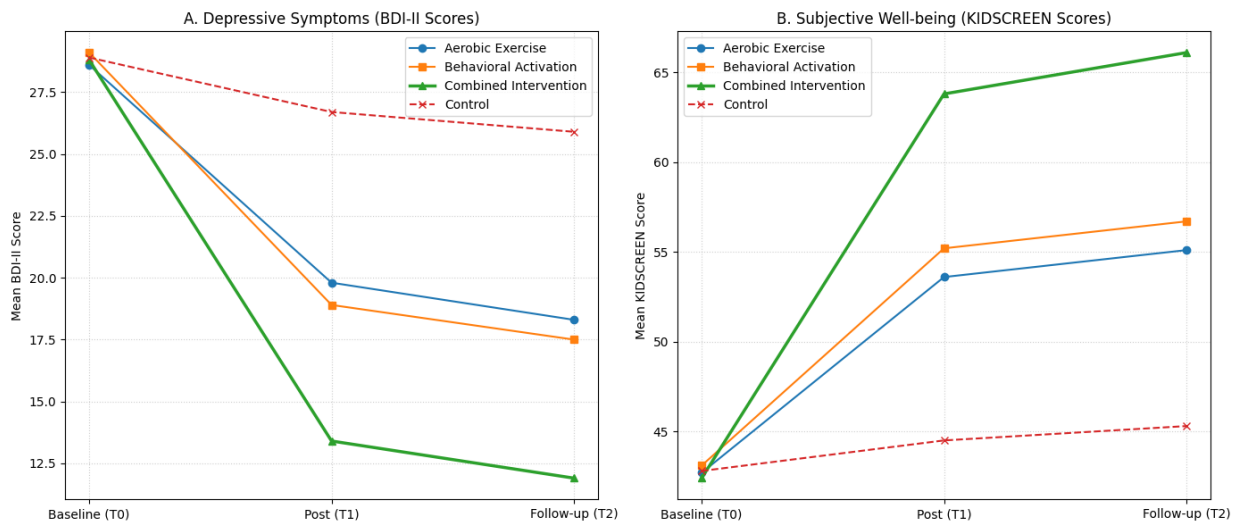


Figure 2. Changes in BDI-II Scores and KIDSCREEN Scores across Three Time Points.

3.6. Pairwise Comparisons at the Three-Month Follow-Up

Compared with the control, AE, and GBAT groups, participants receiving the combined intervention exhibited significantly lower BDI-II scores (all $p < 0.001$) and significantly higher KIDSCREEN scores (all $p <$

0.001). The observed between-group effect sizes were consistently large (Cohen's $d = 0.91$ -1.82), indicating clinically meaningful advantages of the combined intervention. Detailed adjusted mean differences and corresponding 95% confidence intervals are presented in [Table 4](#).

Table 4. Between-Group Comparisons at 3-Month Follow-Up.

Comparison	Mean Difference (95% CI)	p	Cohen's d
Combined vs. Control (BDI-II)	-14.0 (-17.2, -10.8)	< 0.001	1.82
Combined vs. Aerobic (BDI-II)	-6.4 (-9.2, -3.6)	< 0.001	1.03
Combined vs. Behavioral Activation (BDI-II)	-5.6 (-8.4, -2.8)	< 0.001	0.91
Combined vs. Control (KIDSCREEN)	20.8 (16.5, 25.1)	< 0.001	1.76
Combined vs. Aerobic (KIDSCREEN)	11.0 (7.2, 14.8)	< 0.001	1.21
Combined vs. Behavioral Activation (KIDSCREEN)	9.4 (5.7, 13.1)	< 0.001	1.08

4. Discussion

The present study examined the effects of AE, GBAT, and their combination on depressive symptoms and subjective well-being among adolescents with depression. Consistent with the hypotheses, all three active interventions produced significant improvements compared with usual care. Most importantly, adolescents who received the combined intervention experienced significantly greater reductions in depressive symptoms and larger improvements in subjective well-being than those receiving AE or GBAT alone, with these benefits persisting at the three-month follow-up. These findings suggest that integrating AE with GBAT may provide additional therapeutic benefits beyond either intervention delivered in isolation and support the value of multidimensional, non-pharmacological approaches for adolescent depression.

The improvements associated with AE are consistent with previous evidence indicating that regular participation in AE is associated with reduced depressive symptoms among adolescents (19,20). Rather than simply confirming that exercise is beneficial, the present findings extend previous

evidence by demonstrating clinically meaningful improvements within a randomized controlled design using adolescents with elevated depressive symptoms. Exercise likely contributes to symptom improvement through multiple interacting biological and psychological processes. Proposed mechanisms include improved regulation of monoamine neurotransmitters, increased expression of brain-derived neurotrophic factor, reduced systemic inflammation, improved sleep quality, and enhanced stress regulation (24,25,34,35). These mechanisms were not directly evaluated in the present study and should therefore be considered potential rather than confirmed explanations for the observed benefits. In addition, supervised group exercise may promote psychological well-being by strengthening self-efficacy, perceived competence, social connectedness, and confidence (26-28).

Participants receiving GBAT also demonstrated substantial improvements in depressive symptoms and subjective well-being. These findings are consistent with previous evidence showing that GBAT is an effective intervention for adolescent depression (29-31). GBAT is grounded in the principle that increasing engagement in rewarding and value-consistent activities interrupts cycles of avoidance that

maintain depressive symptoms. The group format may have further strengthened treatment effects by promoting peer support, normalization of emotional experiences, collaborative problem-solving, and mutual encouragement. These findings reinforce the growing evidence that relatively straightforward behavioral interventions can effectively improve adolescent mental health while requiring fewer specialized resources than some traditional psychotherapeutic approaches.

The most important contribution of the present study is the demonstration that combining AE with GBAT produced superior outcomes compared with either intervention alone. Several complementary mechanisms may explain this finding. First, AE and GBAT target different yet interconnected determinants of depression. Exercise primarily influences physiological functioning while simultaneously promoting psychological benefits through increased physical competence and social participation. In contrast, GBAT directly addresses maladaptive avoidance patterns by encouraging engagement in meaningful activities and reinforcing adaptive behaviors. The combination of these complementary mechanisms may therefore provide broader therapeutic coverage than either intervention independently.

Second, the findings can be interpreted within established behavioral and motivational frameworks. GBAT proposes that increasing engagement in rewarding activities weakens avoidance behaviors that perpetuate depression, whereas motivational theories such as self-determination theory emphasize the importance of supporting psychological needs to sustain behavioral change. Within the combined intervention, GBAT strategies may have enhanced motivation to participate in exercise by helping adolescents identify personally meaningful goals, overcome barriers, and recognize the relationship between activity and mood. At the same time, successful participation in exercise likely reinforced feelings of competence and accomplishment, thereby strengthening continued engagement in adaptive behaviors. This reciprocal interaction may have created a positive feedback cycle that amplified improvements in both depressive symptoms and subjective well-being.

Third, participation in structured exercise may have provided repeated opportunities for successful GBAT in real-life contexts rather than only discussing behavioral change during therapy sessions. Consequently, adolescents in the combined intervention were able to practice adaptive coping strategies while simultaneously experiencing immediate physiological and emotional benefits associated with regular exercise. This integration of cognitive, behavioral, and physiological processes may explain why the combined intervention consistently outperformed the single-component interventions.

An important aspect of the present study is the inclusion of subjective well-being as a primary outcome alongside depressive symptoms. Contemporary models of mental health emphasize that psychological well-being represents more than simply the absence of psychopathology (9,10). Accordingly, successful treatment should aim not only to reduce distress but also to enhance positive functioning, life satisfaction, emotional well-being, and social adjustment. The substantial improvements

observed in KIDSCREEN scores indicate that all active interventions promoted broader aspects of adolescent functioning beyond symptom reduction alone. Notably, the combined intervention generated the largest improvements in subjective well-being, suggesting that integrated interventions may simultaneously foster recovery from depression and promote positive psychological development.

Although the observed improvements are encouraging, alternative explanations should also be considered. Adolescents participating in the intervention groups received greater attention from instructors and therapists, engaged in regular social interactions with peers, and followed structured weekly routines, all of which may have contributed to improvements independent of the specific intervention components. Similarly, expectancy effects associated with participation in an organized treatment program and increased family support during the intervention period may have influenced outcomes. Although the randomized controlled design reduces the likelihood that these factors fully explain the findings, future studies incorporating active attention-control conditions would help clarify the specific mechanisms responsible for treatment effects.

The present findings have important practical and clinical implications. The results suggest that combining AE with GBAT represents a feasible, relatively low-cost intervention that could complement existing adolescent mental health services. Because both components require modest resources compared with intensive individual psychotherapy, integrated programs may improve access to evidence-based care, particularly in resource-limited settings. Schools represent particularly promising environments for implementation because they provide regular access to adolescents and existing infrastructure for both exercise and psychological support. Collaboration among physical education teachers, school counselors, psychologists, and community health professionals could facilitate the integration of structured exercise and GBAT into comprehensive school mental health programs. Such multidisciplinary approaches may simultaneously promote emotional well-being, physical health, and healthy lifestyle behaviors during a critical developmental period.

This study features several key methodological strengths. The use of a randomized controlled design, comparison against multiple active groups, low attrition rates, and blinded outcome assessments collectively enhance the validity of the findings. Furthermore, evaluating both positive mental health and depressive symptoms offers a balanced perspective on the outcomes. Nonetheless, several limitations must be noted. First, the sample may lack broad representativeness because participants were selected through convenience sampling from schools and clinics in a single Iranian metropolitan area. Second, the use of self-report measures for depression and subjective well-being exposes the data to potential response and social desirability biases. Third, the three-month follow-up period is insufficient to establish the long-term persistence of the treatment effects. Fourth, the nature of the interventions prevented participant blinding, which could introduce expectancy biases. Fifth, unique cultural dynamics, such as family involvement, educational settings, and local attitudes toward exercise and mental health, may affect both

adherence and intervention outcomes. While the basic behavioral and physiological principles should apply globally, replicating this study in other cultural and healthcare contexts is necessary before generalizing the findings. Finally, because biological and behavioral mediators (e.g., self-directed exercise, neurobiological markers, and family support) were not evaluated, the exact mechanisms underlying these improvements remain to be determined.

Future work should prioritize multicenter randomized controlled trials with larger, more heterogeneous samples, extended follow-up intervals, and representation across multiple adolescent age bands. Research that tests delivery within routine school-based mental health services alongside evaluations of cost-effectiveness and the durability of benefits over the long term would strengthen the pathway from efficacy to real-world implementation. Moreover, examining candidate mediators such as adherence to exercise, motivational processes, neurobiological markers, psychosocial adjustment, and family support could help elucidate the mechanisms by which combined interventions enhance mental health in adolescents.

4.1. Conclusion

This study indicates that AE, GBAT, and their combination significantly reduced depressive symptoms and improved subjective well-being among adolescents with depression. Although all active interventions were beneficial, the combined intervention consistently produced the greatest improvements across both outcomes, suggesting that integrating physiological and behavioral approaches may provide additional therapeutic advantages over either strategy alone. These findings support the potential value of combining structured AE with GBAT as an accessible, non-pharmacological intervention that could complement existing adolescent mental health services. Integration of such programs within school- and community-based mental health settings may represent a practical approach for improving both symptom reduction and positive psychological functioning.

Authors' Contribution: The author assumed responsibility for the overall research process, including conceptualization of the study, methodological planning, coordination of the interventions, participant recruitment and assessment, data collection, statistical analysis, interpretation of the results, and manuscript preparation and revision.

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Declaration of Generative AI and AI-Assisted Technologies in the Writing Process: The author declares that no generative artificial intelligence or AI-assisted technology was used in the preparation, writing, editing, or revision of this manuscript. The author assumes full responsibility for the accuracy, originality, integrity, and overall content of the published work.

Ethical Considerations: This study was approved by the relevant institutional ethics committee (Ethics Code:

IR.IAU.TABRIZ.REC.1401.266) and conducted in accordance with the ethical principles of the Declaration of Helsinki. Measures were implemented to protect participants' confidentiality, privacy, dignity, safety, and well-being throughout recruitment, psychological assessment, exercise sessions, behavioral activation therapy, follow-up assessments, and data management. Written informed consent was obtained from the parents or legal guardians of the participating adolescents before enrollment. The adolescents were provided with information appropriate to their age regarding the study procedures and participated voluntarily.

Data Availability: The data supporting the findings of this study are available from the corresponding author upon reasonable request, subject to applicable ethical, privacy, and confidentiality requirements.

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Conflicts of Interest: The author declares that there are no financial, personal, or professional conflicts of interest related to this study.

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