Effect of cognitive-behavioral therapy combined with exercise training in adolescent girls with elevated depression symptoms: a randomized controlled clinical trial

Efecto de la terapia cognitivo-conductual combinada con entrenamiento con ejercicios en adolescentes con síntomas elevados de depresión: un ensayo clínico controlado aleatorizado

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Abstract

Objective: To investigate the effects of cognitive-behavioral therapy (CBT) combined with regular versus intermittent exercise on depression and quality of sleep-in adolescent girls.
Participants and Methods: Sixty adolescent girls aged 12-17 years with mild to moderate depression were equally distributed to three groups, each group 20 patients. Group A received weekly 60-minutes CBT session combined with regular exercise 60 minutes three times per week for 12 weeks; Group B received weekly 60-minutes CBT plus intermittent exercise 60-minutes exercise once per week for 12 weeks and Group C received weekly 60-minute CBT alone for 12 weeks. Participants' depressive symptoms were evaluated before and after the 12-week interventions using the Center for Epidemiologic Studies Depression Scale (CES-D), sleep quality was evaluated before and after 12-week interventions using Pittsburgh Sleep Quality Index (PSQI).
Results: After 12-week interventions, group A showed significantly lower reductions in CES-D depressive symptoms scores compared to group B and group C. Sleep quality improved significantly in all three groups, with group A experiencing the greatest increase. The comparison between groups B and C yielded no significant results. The intragroup statistical evaluation showed no significant difference between the groups.
Conclusion: Among depressed adolescent girls, regular triweekly exercise combined with CBT led to significantly greater decreases in depressive symptoms and improved quality of sleep than intermittent once weekly exercise plus CBT or CBT alone. These findings indicate that exercise frequency may be key in potentiating the antidepressant benefits of CBT.

Keywords

Exercise, cognitive-behavioral therapy, depression, sleep quality, adolescent girls.

Resumen

Objetivo: Investigar los efectos de la terapia cognitivo-conductual (TCC) combinada con ejercicio regular versus intermitente sobre la depresión y la calidad del sueño, en adolescentes.
Participantes y métodos: Sesenta adolescentes de 12 a 17 años con depresión leve a moderada se distribuyeron equitativamente en tres grupos, cada grupo de 20 pacientes. El grupo A recibió una sesión semanal de TCC de 60 minutos combinada con ejercicio regular de 60 minutos tres veces por semana durante 12 semanas; El grupo B recibió TCC semanal de 60 minutos más ejercicio intermitente de 60 minutos una vez por semana durante 12 semanas y el Grupo C recibió TCC semanal de 60 minutos solo durante 12 semanas. Los síntomas depresivos de los participantes se evaluaron antes y después de las intervenciones de 12 semanas utilizando la Escala de Depresión del Centro de Estudios Epidemiológicos (CES-D), la calidad del sueño se evaluó antes y después de las intervenciones de 12 semanas utilizando el Índice de Calidad del Sueño de Pittsburgh (PSQI).
Resultados: Después de intervenciones de 12 semanas, el grupo A mostró reducciones significativamente menores en las puntuaciones de síntomas depresivos CES-D en comparación con el grupo B y el grupo C. La calidad del sueño mejoró significativamente en los tres grupos, y el grupo A experimentó el mayor aumento. La comparación entre los grupos B y C no arrojó resultados significativos. La evaluación estadística intragrupo no mostró diferencias significativas entre los grupos.
Conclusión: Entre las adolescentes deprimidas, el ejercicio regular de tres semanas combinado con TCC condujo a una disminución significativamente mayor de los síntomas depresivos y una mejor calidad del sueño que el ejercicio intermitente una vez a la semana más TCC o TCC sola. Estos hallazgos indican que la frecuencia del ejercicio puede ser clave para potenciar los beneficios antidepresivos de la TCC.

Palabras clave

Ejercicio, terapia cognitivo-conductual, depresión, calidad del sueño, adolescentes.

Introduction

Depression is a psychological disease characterized persistent low mood, which can affect one's vitality, irritability, motivation, and overall capacity for function. Depending on the sort of sadness a person is going through, there are many distinct features of depression (Rushton et al., 2002).

During mid- to late-adolescence, depression represents a widespread mental health issue among teenagers globally, with yearly estimates indicating a prevalence of 4-5% (Babyak et al., 2000). In more than half of adolescent suicide cases, depression is present at the moment of death, accentuating the significance of depression as a critical contributing factor to suicide (Suls & Bunde, 2005). Apart from impairing academic and social performance, depression raises the risk of engaging in obesity, smoking, and substance abuse. Therefore, early detection and effective treatment of this condition are essential. Because adolescent depression has such significant associations with recurrence later in life, it might be thought of as an early-onset sub form of the corresponding adult illness (American Psychological Association, 2021). Additionally, the prevalence of mental illnesses including anxiety and depression rises during adolescence (Zhang et al., 2023).

Cognitive-behavioral therapy (CBT) represents an evidence-based treatment for depression, emphasizing the relationships between one's thoughts, emotions, and behaviors. The goal of CBT is to teach coping skills that challenge negative thinking patterns, harmful actions, and problematic attitudes (Chand & Maerov, 2019). CBT uses both cognitive and behavioral techniques to alleviate depression. Therapists may identify and reframe depressive thought patterns leading to unhelpful behaviors. By changing thoughts, CBT aims to positively influence emotions and behaviors (Gautam et al., 2020). In CBT for adolescent depression, attention can be placed on either cognitive or behavioral skills depending on the individual's needs. Cognitively, CBT addresses negative thinking patterns, distorted thoughts, and maladaptive schemas. Behaviorally, CBT targets skill deficits in coping, social interactions, problem-solving, and enjoyment of activities. Overall, CBT provides depressed adolescents with the cognitive and behavioral skills necessary to establish supportive connections and regulate emotions (Pascoe et al., 2020).

Exercise and physical activity can alleviate symptoms of depression and anxiety, helping people feel better. Once mood improves, exercise may also prevent future episodes of depression and anxiety (Lawlor & Hopker, 2001; Rushton et al., 2002) There are several proposed mechanisms for these antidepressant and anxiolytic effects. Exercise may increase brain chemicals like endorphins, endogenous, cannabinoids, and serotonin that regulate mood, sleep, appetite, and other functions. The release of these natural brain chemicals can improve overall well-being. Additionally, regular physical activity is endorsed in clinical practice guidelines for depressive illnesses, as it may exert inherent antidepressant actions and enhance well-being among those with depressive disorders (Jelalian et al., 2019; Malhi et al., 2021).

According to studies' statistics, 81% of adolescents between the ages of 11 and 17 worldwide did not satisfy the WHO's physical activity recommendations in 2016. Teenage girls were less active than their male counterparts, with 85% of them failing to meet the suggested daily minimum of 60 minutes of moderate-to-intense physical exercise (Chand & Maerov, 2019). It's crucial to emphasize that sedentary behaviors are strongly positively correlated with several health problems, such as melancholy, musculoskeletal discomfort, sleep disruptions, depression and weight problems (Costigen et al., 2012).

Despite these encouraging strategies, there is still a dearth of research, particularly on teenage girls who exhibit higher levels of depression symptoms. Many studies have either focused on more general teenage groups or have overlooked the unique challenges faced by girls in this age range. Additionally, although exercise and cognitive behavioral therapy are beneficial when taken alone, there is no information on their combined effects for this population. The lack of targeted research hinders the development of effective intervention strategies for adolescent girls (Chen & Wang, 2024).

Although previous research has investigated the effect of CBT combined with exercise training on depression (Bourbeau et al., 2020; Heinzel et al., 2022), no studies has explained effect of regular exercise compared with intermittent exercise when combined with CBT for reducing depressive symptoms in adolescent girls. This gap in understanding optimal exercise patterns represents a critical area for further research. Thus, this study aimed to investigate the effects of CBT combined with regular versus intermittent exercise on depression symptoms in adolescent girls with elevated depression. We hypothesized that, among depressed adolescent girls, regular triweekly exercise combined with CBT would

lead to significantly greater reductions in depressive symptoms compared to intermittent weekly exercise plus CBT or CBT alone.

Method

Study design

The study was designed as a randomized controlled trial. It received ethical approval from the Institutional Review Board at the Faculty of Physical Therapy, Cairo University [No: P.T.REC/ 012/004754] and from the ClinicalTrials.gov [NCT06281288] date 28/02/2024. It adhered to the Declaration of Helsinki and was conducted from September 2023 to January 2024. The parents of each participant gave informed consent following a comprehensive briefing on the study's purpose, aims, and possible advantages. They had the option to opt out or leave the study at any point during the investigation while being guaranteed absolute discretion about the provided details.

Participants

Sixty adolescent girls diagnosed with depression participated in this study. They were recruited from an experimental school in Cairo. Inclusion necessitated: (1) an age of 12 to 17 years; (2) a minimum body mass index (BMI) of 25 kg/m2; (3) regular menstruation; (4) an overall score ≥15 on the Center for Epidemiologic Studies - Depression (CES-D) scale, indicating elevated depressive symptoms (Weissman et al., 1980); and (5) good general health based on histories and physical assessment. Exclusion criteria were obesity, malignant diseases, psychotic disorders or psychosis, and permanent long-term psychiatric medication use.

Randomization

An independent individual randomized participants into three groups using sealed envelopes prepared with numbers from a random number generator: group (A) received CBT plus regular exercise three times weekly (n=20), group (B) received CBT plus intermittent exercise once weekly (n=20), and group (C) received only CBT (n=20). To maintain an equal distribution of participants across the groups, the randomization process utilized permuted blocks. Participants were randomized using permuted block randomization with a block size of 4 to ensure balance between groups throughout the enrollment period and reduce the risk of predictability. The randomization sequence was generated using a computerized random number generator (e.g., via Randomization.com or similar software) by an independent researcher not involved in participant enrollment or data collection. To maintain allocation concealment, sealed, opaque, and sequentially numbered envelopes were used to assign participants to study arms. Following this random assignment, there were no dropouts from the study (Figure 1).

Interventions

Participants were randomly assigned to three groups. Group A received a combined intervention consisting of a weekly 60-minute cognitive behavioral therapy (CBT) session, in addition to a structured exercise program. This exercise regimen comprised three 60-minute sessions per week for 12 weeks, with each session including 10 minutes of warm-up, 20 minutes of aerobic exercise, 20 minutes of resistance training, and 10 minutes of cool-down.

Similarly, Group B participated in a weekly 60-minute CBT session along with an intermittent exercise program, defined as one 60-minute exercise session per week over 12 weeks. Each of these sessions followed the same structure as Group A, including 10 minutes of warm-up, 20 minutes of aerobic exercise, 20 minutes of resistance exercise, and 10 minutes of cool-down.

Group C attended only the weekly 60-minute CBT sessions for 12 weeks, with no exercise component.

Cognitive behavioural therapy (CBT)

All participants in all groups received a weekly 60-minute CBT session. The CBT techniques were co-facilitated by a psychiatrist over the 12-week intervention. The 60-minute weekly sessions provided psychoeducation on thought-emotion-behavior connections, techniques for self-monitoring, strategies for reshaping negative thinking patterns, methods to increase participation in enjoyable activities, ways

to practice self-reinforcement, and training in coping skills (Burton et al., 2007; Stice et al., 2007; Stice et al., 2008; Shaffer, 2014).

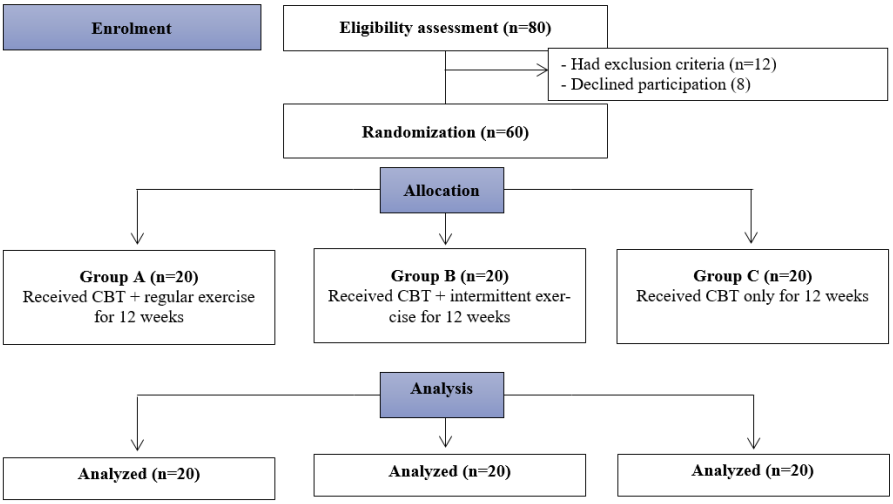
Exercise training

Both groups (A and B) participated in exercise sessions that were identical in terms of activities and structure but differed in terms of weekly frequency. Group A engaged in regular exercise training, performing 60-minute sessions 3 times per week, while Group B performed intermittent training with 60-minute sessions once weekly. All other exercise parameters were equivalent between groups. The 12-week intervention utilized heterogeneous exercise programming, allowing participants to choose enjoyable aerobic and resistance activities.

For aerobic exercise, options included walking stationary, ergometric, or recumbent biking, swimming, jogging, and treadmill use. Intensity about 55–65% of HRmax and duration 20 minutes per session. In addition, resistance exercise Involving lateral pull downs, bench presses, biceps curls, abdominal crunches, leg presses, hip abductions, and calf raises. These used free weights and gym machines.

Low to moderate intensity, targeting 65–70% of the one-repetition maximum (1RM). Progressed gradually over three stages. The progression involved starting with 1–2 sets of 8–12 repetitions per exercise in the initial stage, increasing to 2–3 sets of 10–15 repetitions in the second stage, and finally reaching 3 sets of 12–15 repetitions in the last stage. Frequency, three sessions per week, for 12 weeks (Rogers et al., 2007).

Figure 1. Flow chart of the participants during the trial



Outcome measures

Primary Outcome Measure

Center for Epidemiologic Studies Depression Scale (CES-D)

It was used to assess depressive symptoms before and after the 12-week interventions. This 20-item self-report questionnaire evaluates depressive symptoms and symptom improvement across pediatric and adolescent populations, specifically ages 12 through 17. It has demonstrated high internal consistency with a Cronbach's alpha of 0.85 in the general population and good test-retest reliability. Each response corresponds to a score ranging from 0 to 3, where 0 signifies "Not at All," 1 indicates "A Little," 2 denotes " Some," and 3 represents " A Lot." Notably, questions 4, 8, 12, and 16 are reversely coded due to their positive wording. Consequently, CES-D scores vary between 0 and 60, with greater values suggesting more severe levels of depressive symptoms (Binder et al., 2011).

Secondary Outcome Measure

Pittsburgh Sleep Quality Index (PSQI)

Sleep quality (by Pittsburgh Sleep Quality Index (PSQI): The PSQI is a tool designed for assessing sleep quality in clinical populations, consisting of 19 self-reported items subdivided into seven categories: subjective sleep quality, sleep latency, duration of sleep, habitual sleep efficiency, disturbances during sleep, use of sleep aids, and daytime impairment. It exhibits strong internal reliability (α = 0.83) and test-retest reliability (0.85 for the global scale). Additionally, it demonstrates high sensitivity (89.6 %) and specificity (86.5 %) in evaluating overall sleep quality. Higher scores indicate poorer sleep quality, with categories for very good, good, poor, and very poor sleep quality based on the global score (Holt-grefe, 2012).

Sample size calculation and statistical analysis

The study's sample size was determined using the G*power program 3.1.9 (G power program version 3.1, Heinrich-Heine-University, Düsseldorf, Germany). The effect size for the sample size calculation was based on previous research [13]. The sample size calculation utilized t tests - Means: Difference between two independent means (two groups), with assuming a medium effect size (d = 0.5), Type I error (α) of 0.05, power (1-β error probability) of 0.80 and an effect size d=0.921. This calculation aimed for a total sample size of 40 participants for comparing depression as the primary outcome across 2 independent groups. A total sample size is 60 patients for 3 groups, with 20 patients per group. Quantitative data for clinical general characteristics (age, weight, height, and BMI) along with CES-D scale were collected. and cognitive function data were screened, for normality assumption test and homogeneity of variance. Normality test of data using Shapiro-Wilk test was used, that reflect the data was normally distributed (P>0.05) after removal outliers that detected by box and whiskers plots. Additionally, Levene's test for testing the homogeneity of variance revealed that there was no significant difference (P>0.05). The data is normally distributed and parametric analysis is done. Quantitative data expressed as mean and standard deviation for patients demographic data, CES-D scale, and cognitive function. Paired t-tests compared between pre- and post-treatment within each group. One-way analysis of variance (ANOVA) test compared among groups A, B, and Cat before- and after-treatment. Post-hoc Bonferroni correction compared pairwise groups for CES-D scores and cognitive function when ANOVA test yielded significance. Effect size calculation by Cohen's d within each group between before- and after-treatment which considered a value of 0.2 represents a small effect size, value of 0.5 represents a medium effect size, and value of 0.8 represents a large effect size. Moreover, effect size calculated among 3 groups at before and after treatment by Eta square, a value around 0.01 indicates a small effect, 0.06 a medium effect, and 0.14 a large effect. Statistical analyses were performed using SPSS Version 25 for Windows (SPSS, Inc., Chicago, IL), with significance set at P ≤ 0.05 throughout all analyses.

Results

The present study sample comprised 60 patients, randomly and evenly allocated into 3 groups of 20 participants each. No statistically significant among -group differences existed at baseline across Groups A, B and C regarding age (P=0.075), weight (P=0.834), height (P=0.933), or BMI (P=0.801) parameters (Table 1).

Table 1. Patient clinical general characteristics among groups

Variables	Groups			F-value	*P*-value
	Group A (n=20)	Group B (n=20)	Group C (n=20)		
Age (year)	15.95 ±1.90	15.89 ±1.58	14.80 ±1.79	2.707	0.075
Weight (kg)	62.70 ±7.37	62.25 ±5.03	61.45 ±7.25	0.182	0.834
Height (cm)	153.20 ±6.92	152.85 ±5.95	152.40 ±7.50	0.069	0.933
BMI (Kg/cm^2)	26.71 ±1.12	26.64 ±1.22	26.45 ±1.44	0.223	0.801

Data are reported as mean ±standard deviation and compared statistically by ANOVA test; P-value: probability value; P-value>0.05: non-significant.

Intragroup statistical evaluation for CES-D scale (Table 2 and Figure 1) revealed significant declines (P<0.05) in CES-D scores from baseline to post-treatment measures within all three groups A, B, and C (P=0.0001). with large effect sizes for group A (2.50), group B (1.24) and group C (0.80). The mean differences (95% CI) of CES-D scale for groups A, B, and C were 15.15 (CI 13.48–16.81), 6.45 (CI 6.01–6.89), and 4.70 (CI 3.57–5.82), respectively. Intergroup statistical evaluation for sleep quality (Table 2 and Figure 2) revealed significant increase (P<0.05) in sleep quality from baseline to post-treatment measures within all three groups A, B, and C (P=0.0001) with large effect sizes for group A (1.01) and group B (0.81) and small effect size for group C (0.33).

Moreover, the patients in Group A showed the greatest improvement in CES-D scores and sleep quality (40.34% and 36.95%, respectively) followed by patients in Group B (17.31% and 14.46%, respectively), and then those in Group C (12.14% and 7.38%, respectively).

Statistical analysis among groups for CES-D scale (Table 2 and Figure 1) and sleep quality (Table 2 and Figure 2) revealed no significant differences (P>0.05) among the three groups before-treatment in CES-D scale (P=0.692) and sleep quality (P=0.915). with small effect size (0.007 and 0.089, respectively). However, there was a significant difference (P<0.05) among the three groups after treatment in CES-D scale (P=0.0001) and sleep quality (P=0.0001). with large effect size (0.30 and 0.15, respectively). Post-treatment CES-D scores showed the greatest decrease in Group A (22.40 ±5.04), followed by Group B (30.80 ±5.30), and then Group C (34.00 ±4.57). While, post-treatment sleep quality showed the greatest increased in Group A (19.68 ±6.99), followed by Group B (16.62 ±2.79), and then Group C (15.27 ±3.11).

Table 2. Within and among groups comparison for CES-D scale and sleep quality

Variables	Items	Groups (Mean ±SD)			95% CI	Effect size	F-value	P value2
		Group A (n=20)	Group B (n=20)	Group C (n=20)				
CES-D scale	Before-treatment	37.55 ±6.89	37.25 ±5.05	38.70 ±4.66	36.47 – 39.19	0.007		
	After-treatment	22.40 ±5.04	30.80 ±5.30	34.00 ±4.57	27.70 – 30.42	0.30	0.370	0.692
	Change (MD)	15.15	6.45	4.70			28.897	0.0001*
	Improvement %	40.34%	17.31%	12.14%				
	95% CI	13.48 – 16.81	6.01 – 6.89	3.57 – 5.82				
	Effect size	2.50	1.24	0.80				
	t-value	19.042	30.54	8.728				
Sleep quality	Before-treatment	14.37 ±2.51	14.52 ±2.31	14.22 ±3.20	13.13 – 14.92	0.001	0.089	0.915
	After-treatment	19.68 ±6.99	16.62 ±2.79	15.27 ±3.11	16.31 – 18.11	0.15	9.959	0.0001*
	Change (MD)	5.31	2.10	1.05				
	Improvement %	36.95%	14.46%	7.38%				
	95% CI	4.37 – 6.25	1.92 – 2.28	0.61 – 1.46				
	Effect size	1.01	0.81	0.33				
	t-value	8.563	6.682	4.992				

Data are expressed as mean ± standard deviation (SD) MD: Mean difference CI: Confidence interval
Improvement % = (MD / Before-treatment mean) x 100 P-value: probability value * Significant (P<0.05)
P-value1: Probability value within each group by paired t-test P-value2: probability value among groups by ANOVA test

Figure 1. Mean values of CES-D scale in Groups A, B, and C

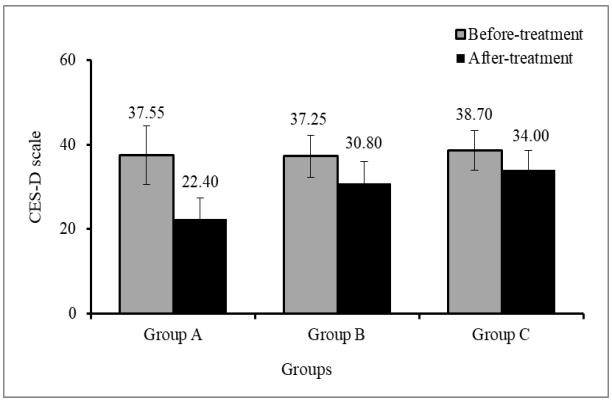
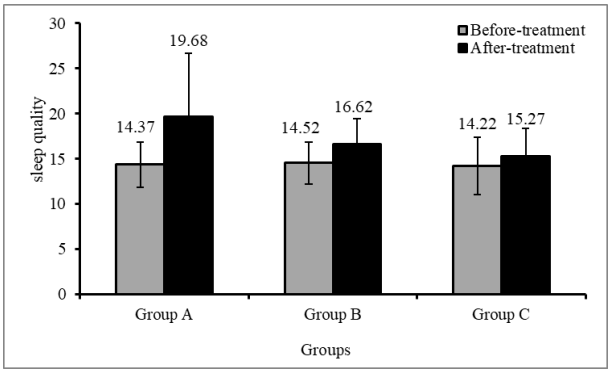


Figure 2. Mean values of sleep quality in Groups A, B, and C.



Post hoc analyses indicated significant between-group differences when comparing Group A versus B (MD=8.40; 95% CI 4.51–12.29; P=0.0001) and Group A versus C (MD=11.60; 95% CI 7.71-15.49; P=0.0001) on post-treatment CES-D scores. However, Group B versus C comparisons showed no significant difference in CES-D scores (MD=3.20; 95% CI (-0.69-7.09; P=0.141). There were significant differences when comparing Group, A versus B (MD=3.06; 95% CI 1.18 – 4.94; P=0.0001) and Group A versus C (MD=4.41; 95% CI 2.44 – 6.38; P=0.0001) on post-treatment sleep quality. However, Group B versus C comparisons showed no significant difference in sleep quality (MD=1.35; 95% CI -0.60 – 3.30; P=0.107). Post-hoc analyses and mean differences between groups denoted that Group A achieved the greatest CES-D scale and sleep quality enhancements (Table 3).

Table 3. Pairwise comparison (post hoc test) between groups for CES-D scale

Variables	Items	Post-hoc test (after-treatment)		
		Group A vs. Group B	Group A vs. Group C	Group B vs. Group C
CES-D scale	MD (Change)	8.40	11.60	3.20
	95% CI	4.51 – 12.29	7.71 – 15.49	-0.69 – 7.09
	P-value	0.0001*	0.0001*	0.141
(PSQI) scale	MD (Change)	3.06	4.41	1.35
	95% CI	1.18 – 4.94	2.44 – 6.38	-0.60 – 3.30
	P-value	0.0001*	0.0001*	0.107

MD: Mean difference; CI: confidence Interval; * Significant (P<0.05); P-value: probability value between pairwise groups by Bonferroni correction test

Discussion

This study evaluated the impacts of CBT combined with different exercise regimen on depressive symptoms in female adolescents. The patients in Group A showed the greatest improvement in CES-D scores and sleep quality (40.34% and 36.95%, respectively) followed by patients in Group B (17.31% and 14.46%, respectively), and then those in Group C (12.14% and 7.38%, respectively).

Our results demonstrated significant improvement in depression and sleep quality across all groups, with regular triweekly exercise combined with CBT being the most effective, compared to intermittent exercise combined with CBT, and finally CBT alone. These findings suggest that while CBT alone can improve depressive symptoms and sleep quality, the addition of regular exercise provides enhanced benefits.

Regarding the beneficial effect of CBT, Rogers, (2007) emphasized the therapist's authenticity as a critical component in developing a therapeutic connection. This corroborates the findings from Gorka et al. (2019), where adolescents responded well to CBT when they perceived the therapist as honest. Adolescents may face increased vulnerability at the beginning of therapy before a trusting relationship with the therapist is formed (Buysse et al., 1989).

The advantages of both aerobic and resistance training are combined, while the resistance training component increases muscle strength and joint stability (Rahman, 2024), which lessens discomfort from muscle weakness and improves sleep efficiency, the aerobic component increases metabolic rate and

cardiovascular function (Gupta et al., 2022). Even though the aerobic and resistance exercises have many health advantages, its ability to alter the neuroendocrine system is not as strong or direct as Pilates, which leads to a marginally smaller overall improvement in sleep quality.

A systematic review revealed that the brain regions most commonly affected by CBT were the left anterior cingulate cortex, posterior cingulate cortex, and orbitofrontal cortex/dorsomedial prefrontal cortex. The observed decrease in dorsal anterior cingulate activity after CBT aligns with an information processing model proposing separate ventral affective and dorsal cognitive neural circuits (Morres et al., 2019). Additionally, research found reduced neural responses in the insula and amygdala when perceiving emotions after CBT treatment in anxious and depressed adolescents. This dampened limbic activity correlated with greater clinical improvement (Korczak et al., 2017).

The enhanced antidepressant benefits of adding regular exercise in adolescents could be supported by previous research which revealed that the frequency of exercise programs may influence their effectiveness. The Canadian government's general health promotion guidelines, as well as the American Academy of Pediatrics, prescribe a minimum of one hour of moderate to strenuous exercise 3 times per week to preserve physical and mental health (Hale et al., 2023).

Various perspectives explain the favorable impact of exercise on adolescent depression alleviation. Physiologically, exercise improves monoamine synaptic transmission and stimulates endorphin release (Yeung, 1996), which inhibits central nervous system activity leading to reduced pain and increased brain function, improving mood (Hendrikse et al., 2022). Exercise also increases brain-derived neurotrophic factor, promoting hippocampal neurogenesis and synaptic plasticity, and regulates cortisol and interleukin-6 to improve hypothalamic-pituitary-adrenal feedback control (Kliziene et al., 2021). Psychologically, exercise can provide a distraction from negative thoughts, improving mood during and after the activity. Achieving success in the challenging activity of exercise can boost self-esteem (self-efficacy perspective) (El-Sayed et al., 2025). Exercise boosts social support, self-esteem, and sleep quality while lowering stress and anxiety (Hossain et al., 2024).

Strengths and limitations

The study exhibits some strengths, such as its randomized controlled design and the use of a validated scale to assess depressive symptoms. However, it also has some limitations. Its focus solely on adolescent girls with depression restricts the generalizability of the findings to other demographic groups. Additionally, the short 12-week follow-up period limits insights into the longer-term effects of the interventions. Future studies should implement high-quality, long-term randomized controlled trials with extended follow-up periods to investigate the lasting effects of exercise interventions over time.

Conclusions

The combination of CBT with regular triweekly exercise resulted in significantly larger decreases in depressive symptoms and improved quality of sleep on the CES-D scale compared to those undergoing CBT plus intermittent once weekly exercise or CBT alone among adolescent girls with elevated depression symptoms. The lack of significant differences between groups receiving CBT with intermittent exercise and CBT alone suggests that the frequency of exercise is a critical factor in enhancing the therapeutic effects of CBT on depression and quality of sleep.

Abbreviations

Cognitive-Behavioral Therapy (CBT)

Center for Epidemiologic Studies Depression Scale (CES-D)

Body Mass Index (BMI)

Maximum Heart Rate (HR max)

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Competing Interests

The authors declare no conflicts of interest with any financial entities regarding the content presented in this manuscript.

Data Availability

Upon reasonable request, the corresponding author can provide the datasets used and analyzed during this study.

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