International Journal of Community Medicine and Public Health
Kaewumpa P et al. Int J Community Med Public Health. 2026 Apr;13(4):1621-1628
http://www.ijcmph.com
pISSN 2394-6032 | eISSN 2394-6040

DOI: https://dx.doi.org/10.18203/2394-6040.ijcmph20260754

Original Research Article

Effects of a school-based group exercise program on depressive symptoms in adolescents with overweight and obesity: a quasi-experimental study

Poramaporn Kaewumpa[1], Kod Phithakwongrojn[1], Tatree Bosittipichet[1], Thanakamon Leesri[2]*

[1]Department of Social Medicine, Phra Nakhon Si Ayutthaya Hospital, Phra Nakhon Si Ayutthaya, Thailand
[2]Nursing Institution, Suranaree University of Technology, Thailand

Received: 05 February 2026
Revised: 06 March 2026
Accepted: 07 March 2026

***Correspondence:**
Dr. Thanakamom Leesri,
E-mail: thanakamon@sut.ac.th

ABSTRACT

Background: Adolescent obesity and depression are escalating public health concerns. However, evidence regarding the efficacy of supervised group-based exercise specifically for adolescents with comorbid overweight/obesity and depression remains limited. Objectives were to evaluate the effectiveness of a moderate-intensity group-based aerobic exercise program on depressive symptoms and nutritional status in high-risk adolescents.
Methods: This quasi-experimental study enrolled 48 junior high school students in Phra Nakhon Si Ayutthaya, Thailand, who presented with overweight or obesity [BMI-for-age Z-score (BAZ) >+1 SD] and mild-to-moderate depression [Children's depression inventory (CDI) score ≥16]. Participants engaged in a supervised aerobic exercise program (30 minutes/session, 3 times/week) for 4 weeks. Outcomes, including CDI scores, body mass index (BMI), and waist circumference, were assessed at baseline, week 4, and week 12. Data were analyzed using the Friedman test and Wilcoxon signed-rank test with Bonferroni correction.
Results: At the 12-week follow-up, CDI scores significantly decreased compared to baseline (p=0.016). Similarly, a significant reduction in BMI was observed (p=0.002). Although a significant overall variation in waist circumference was detected (p=0.006), pairwise comparisons did not reach statistical significance after correction.
Conclusions: A school-based, supervised group exercise program effectively reduced depressive symptoms and BMI in adolescents with co-occurring obesity and depression. This intervention serves as a promising adjunctive strategy for integrated mental and physical health promotion within school health systems and primary care networks.

Keywords: Adolescent depression, Childhood obesity, Group exercise, School mental health, Adjunctive intervention

INTRODUCTION

Overweight and obesity in children and adolescents represent an escalating global public health crisis. In 2022, it was estimated that over 390 million children and adolescents aged 5-19 years were overweight, with more than 160 million classified as obese.[1] In the context of Southeast Asia, data from the Department of Health, Ministry of Public Health of Thailand (February 16, 2023), indicates that Thai children exhibit one of the highest prevalence rates of overweight and obesity in the ASEAN region.[2] Specifically, health region 4 has reported the highest prevalence of pre-obesity and obesity among children and adolescents in the country.[3,4]

The repercussions of childhood obesity are multidimensional, adversely affecting both physical and psychosocial well-being. Psychologically, children with excess weight often suffer from low self-esteem, negative body image, and social maladjustment, all of which are closely correlated with feelings of isolation, anxiety, and depression. Physiologically, obesity significantly

heightens the risk of non-communicable diseases (NCDs), including diabetes mellitus, hypertension, dyslipidemia, as well as complications involving the respiratory, gastrointestinal, musculoskeletal, and dermatological systems.[5]

Epidemiological evidence strongly underscores the association between obesity and mental health disorders. A study by Lindberg et al. reported that compared to their normal-weight peers, girls with obesity had a 43% higher risk of developing anxiety and depression, while the risk was 33% higher in boys.[6] Furthermore, Schwimmer et al. demonstrated that the health-related quality of life (HRQoL) in children with obesity is five times lower than that of healthy children, a level comparable to that observed in pediatric cancer patients.[7]

Although numerous studies suggest that regular physical activity improves physical fitness and exerts positive effects on mood and mental health in youths, empirical evidence regarding the impact of "supervised exercise programs" specifically on depression among adolescents with obesity remains limited.[8,10] Notably, a study by Daley et al found that while more than 30% of adolescents with obesity had CDI scores indicating emotional disturbance, and over a quarter reported self-harm ideation, the exercise intervention did not yield a significant reduction in CDI scores, despite improvements in self-esteem and physical activity levels.[8] Consequently, the researchers suggested that future studies should specifically target populations with "pre-existing depressive symptoms" to directly evaluate the therapeutic efficacy of exercise.

Addressing this knowledge gap, this study aims to evaluate the effectiveness of a group-based exercise program on depressive symptoms among adolescents with overweight or obesity who present with concomitant mild depression (CDI≥16). Conducted within a primary care network, this research seeks to support mental health promotion strategies for at-risk populations and provide evidence-based recommendations for the implementation of health services in Thailand.

Primary objectives

Primary objectives were to evaluate the effectiveness of a moderate-intensity group-based aerobic exercise program on changes in depressive symptoms, as measured by the CDI, among adolescents aged 12-15 years with overweight or obesity.

Secondary objectives

Secondary objectives were to assess the effect of the moderate-intensity group-based aerobic exercise program on changes in BMI among adolescents aged 12-15 years with overweight or obesity and to assess the effect of the moderate-intensity group-based aerobic exercise program on changes in waist circumference among adolescents aged 12-15 years with overweight or obesity.

METHODS

Study design

This study employed a quasi-experimental, single-group pre-test/post-test design targeting adolescents aged 12-15 years with overweight or obesity and concomitant mild depression. The exact study period, encompassing screening, the exercise intervention, and follow-up assessments, was conducted from December 2024 to May 2025.

Setting

The study was conducted in junior high schools located in Phra Nakhon Si Ayutthaya District, Phra Nakhon Si Ayutthaya Province, Thailand, which falls within the catchment area of the local primary care network. Screening and data collection procedures were performed on-site at the schools, facilitated by collaboration with school administrators and designated project teachers. The group-based exercise program was conducted within the school premises under the supervision of a fitness instructor. This setting was selected to align with the educational context, ensure accessibility, and promote high adherence among student participants.

Inclusion criteria

Participants were eligible for inclusion if they met all the following criteria: Students aged 12-15 years currently enrolled in schools within the catchment area of the primary care network in Phra Nakhon Si Ayutthaya Province. Classified as having overweight or obesity according to the world health organization (WHO) 2007 reference for BAZ:[1]

Overweight: BAZ >+1 to +2 standard deviations (SD).

Obesity: BAZ ≥+2 SD.

A CDI score of ≥16. This cut-off indicates mild depressive symptoms and has been validated for use in the Thai population according to the clinical practice guideline for adolescents with depression.[12] Provision of written informed consent from legal guardians and written assent from the students. Ability to participate in the scheduled exercise sessions without any physical limitations contraindicating moderate-intensity exercise.

Exclusion criteria

Participants were excluded if they met any of the following criteria: Presence of any underlying physical or psychiatric conditions assessed by a physician as barriers to exercise or confounders affecting mental health assessment. Current treatment with psychotropic

medications (e.g., antidepressants, mood stabilizers) or undergoing psychotherapy within 3 months prior to enrollment. History of unresolved musculoskeletal injuries or being in a recovery phase requiring activity restriction. Inability to commit to attending at least 80% of the scheduled exercise sessions. Refusal to provide personal data or complete the study questionnaires.

Sample size estimation

Sample size estimation was based on findings by Daley et al who investigated the effects of a supervised exercise program on mental health in adolescents with obesity.[8] Their study compared CDI scores pre- and post-intervention, reporting a reduction in mean scores from 11.1±6.04 at baseline to 7.68±1.07 after 8 weeks, reflecting a downward trend in depressive symptoms. Based on these data, a medium effect size (Cohen's d=0.50) was anticipated for this study.

The sample size was calculated using G*Power software version 3.1.9.7, utilizing the t-test family for the difference between two dependent means (matched pairs), which is appropriate for a single-group repeated measures design. The parameters were set as follows: effect size (Cohen's dz) =0.50, significance level α=0.05, and power 1–β=0.90. The a priori analysis indicated that a minimum of 44 participants was required to detect a moderate difference in CDI scores. In the actual study, 48 participants were enrolled, yielding a calculated post-hoc power of approximately 0.93, which exceeds the standard requirement. Thus, the sample size was deemed sufficient to strictly detect significant changes in primary outcome.

Instruments

Outcomes were assessed using standardized instruments covering mental health status, anthropometric parameters, and baseline characteristics.

CDIs

Depressive symptoms were evaluated using the Thai version of the CDI. This 27-item self-report scale quantifies the severity of depressive symptoms in children and adolescents. Participants completed the questionnaire under the supervision of the research team. Higher total scores indicate greater severity of depression. For this study, a cut-off score of ≥16 was established to identify participants with at least mild depression. The CDI is widely utilized in pediatric mental health research and has demonstrated good validity and reliability.

BMI

Anthropometric measurements followed a standardized protocol. Body weight was measured using a digital scale, and height was measured using a stadiometer. Participants were required to remove their shoes and wear light clothing during measurements. BMI was calculated as weight in kilograms divided by the square of height in meters (kg/m^2). Nutritional status was classified based on the WHO 2007 BAZ criteria, defining overweight as a BAZ >+1 to +2 SD and obesity as a BAZ ≥+2 SD.

Waist circumference

Waist circumference was measured using a non-stretch measuring tape. Measurements were taken at the midpoint between the lowest rib and the iliac crest while the participant stood in an upright position at the end of normal expiration. Values were recorded in centimeters. To minimize measurement error, the same technique was consistently applied across all assessment points.

Demographic and health behavior questionnaire

A study-specific questionnaire was developed to collect baseline demographic and health-related data, including age, sex, underlying diseases, parental marital status, physical activity habits, sleep patterns, smoking or e-cigarette use, and alcohol consumption.

Study procedures

The study was conducted among junior high school students in Phra Nakhon Si Ayutthaya District, Phra Nakhon Si Ayutthaya Province. The procedural timeline was as follows:

Screening and enrollment

Initial screening was conducted on December 26, 2027. A total of 274 students underwent anthropometric assessment (weight and height) to classify nutritional status according to the WHO 2007 BAZ criteria. Mental health status was assessed using the Thai version of the CDI. Students meeting the inclusion criteria (CDI≥16 and classified as overweight or obese) who expressed willingness to participate were enrolled. Written informed consent was obtained from parents, and written assent was obtained from the students after a detailed explanation of the study protocol.

Baseline assessment and health education

Prior to the intervention, a health education session was organized to provide knowledge on appropriate nutrition and the benefits of physical activity for adolescents, aiming to enhance motivation for behavioral modification. Baseline data collection was performed on December 26, 2027, encompassing demographic data, underlying diseases, complications, physical activity habits, anthropometric measurements (weight, height, waist circumference), and CDI scores.

Intervention phase

The exercise intervention commenced in February 2028. Forty-eight participants engaged in a moderate-intensity

aerobic exercise program, conducted three times per week for 4 consecutive weeks (totaling 12 sessions). All sessions were supervised by a fitness instructor experienced in adolescent training. Each 30-minute session comprised: Warm-up: 5 minutes, main aerobic exercise: 20 minutes and cool-down: 5 minutes researchers monitored attendance and ensured participant safety throughout the intervention period.

Post-intervention assessment (week 4)

Upon completion of the 4-week program, a post-intervention assessment was conducted on March 24, 2028. Outcome measures, including weight, height, BMI, waist circumference, and CDI scores, were re-evaluated to determine immediate changes compared to baseline.

Follow-up assessment (week 12)

To evaluate the sustainability of the outcomes, a follow-up assessment was conducted on May 19, 2028. The same parameters (CDI scores, BMI, and waist circumference) were measured to analyze trends in mental and physical health over the 12-week period.

Statistical analysis

Data integrity and completeness were verified prior to analysis. Statistical processing was performed using STATA version 17 (StataCorp, college station, TX). Descriptive statistics were used to summarize baseline characteristics: continuous variables (e.g., CDI scores, BMI, waist circumference) were reported as median and interquartile range (IQR) due to the non-normal distribution of the data, while categorical variables (e.g., sex, comorbidities, health behaviors) were presented as frequencies and percentages (n, %).

To evaluate changes in outcomes across the three time points (baseline, week 4, and week 12), the Friedman test was employed for within-group repeated measures analysis. Upon detecting statistical significance ($p<0.05$), post-hoc pairwise comparisons were conducted using the Wilcoxon signed-rank test. To control for type-I error inflation due to multiple comparisons, a Bonferroni correction was applied, setting the significance threshold for pairwise comparisons at $p<0.017$. Boxplots were generated to visualize the distribution and trends of CDI scores, BMI, and waist circumference throughout the follow-up period.

Ethical considerations

This study was reviewed and approved by the institutional review board/ethics committee prior to commencement. The study protocol adhered to ethical standards for human research. All participants and their legal guardians were provided with detailed information regarding the study's objectives, procedures, and potential benefits. It was explicitly stated that participation was voluntary and that participants reserved the right to withdraw from the study at any time without any negative repercussions on their educational standing or access to health services.

Confidentiality was strictly maintained by anonymizing personal data with identification codes. All electronic data were stored in password-protected files accessible solely by the principal investigator. Study findings are reported as aggregate data to ensure participant anonymity.

Regarding safety measures, the exercise intervention was designed at a moderate intensity and conducted under the direct supervision of an experienced fitness instructor. A safety protocol was established wherein exercise would be immediately terminated if a participant exhibited adverse symptoms such as dyspnea, excessive fatigue, or dizziness, with a school nurse available on-site for immediate primary care. Written informed consent was obtained from parents, and written assent was obtained from students prior to enrollment. The consent documentation included the right to be informed of study results upon completion and a guarantee that data would be used exclusively for the purposes of this research.

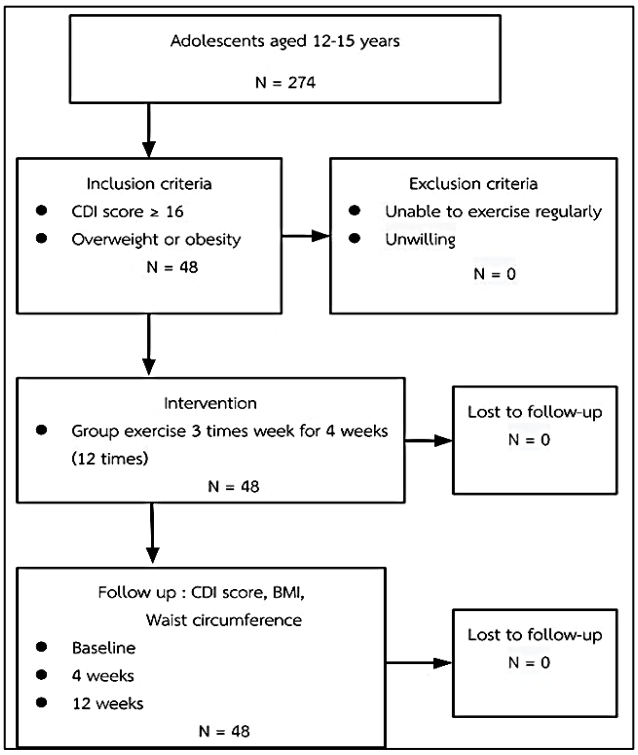

Figure 1: Presentation of the study flow.

RESULTS

Baseline characteristics of participants of the 274 junior high school students screened, 48 individuals met the inclusion criteria-defined as having a BAZ>+1 SD (indicating overweight or obesity) and a CDI score of ≥16 and voluntarily enrolled in the study.

The cohort comprised an equal distribution of males and females (50.0%), with a median age of 13.00 years (IQR: 13.00-14.00). Regarding socio-demographic factors, the majority of participants (72.9%) resided with parents who were living together. Clinically, 83.3% of the participants reported no underlying medical conditions.

In terms of health behaviors, the prevalence of substance use was low; 93.8% reported no smoking or e-cigarette use, and 83.3% reported no alcohol consumption. However, regarding lifestyle habits, 18.8% reported experiencing insufficient sleep. Notably, at baseline, only 54.2% engaged in regular physical activity. These baseline characteristics delineate a vulnerable adolescent population presenting with excess weight and concomitant mental health concerns, accompanied by suboptimal health-promoting behaviors, which aligns precisely with the target demographic for this exercise intervention.

Effects of exercise intervention on depressive symptoms (Primary outcome)

Following the group-based exercise intervention, a decreasing trend in depressive symptoms was observed. The median (IQR) CDI scores declined from 20.00 (17.00-24.00) at baseline to 20.00 (13.50-23.00) at week 4, and further to 17.50 (12.75-23.00) at week 12. Although the overall comparison across the three time points using the Friedman test did not reach statistical significance (p=0.203), post-hoc pairwise comparisons utilizing the Wilcoxon signed-rank test with Bonferroni correction revealed a statistically significant reduction in CDI scores at week 12 compared to baseline (p=0.016). No significant differences were observed between baseline and week 4 (p=0.103) or between week 4 and week 12 (p=1.000).

Effects of exercise intervention on bmi and waist circumference (Secondary outcomes)

Regarding BMI, the median (IQR) values were 27.26 (24.97-31.23) at baseline, 27.36 (24.43-30.47) at week 4, and 26.83 (23.35-30.09) at week 12. The Friedman test indicated a significant difference across the time points (p=0.004). Subsequent pairwise comparisons with Bonferroni correction demonstrated a significant decrease in BMI at week 12 compared to baseline (p=0.002). Comparisons between baseline and week 4 (p=0.063) and between week 4 and week 12 (p=0.200) were not statistically significant.

For waist circumference, the median (IQR) decreased slightly from 87.28 (78.10-93.98) cm at baseline to 86.36 (78.08-93.98) cm at week 4, remaining at 86.36 (77.55-93.98) cm at week 12. While the Friedman test showed a significant overall difference (p=0.006), post-hoc pairwise comparisons with Bonferroni correction failed to identify significant differences for any specific pairs (Baseline vs week 4, p=0.129; week 4 vs week 12, p=0.539; Baseline vs week 12, p=0.083).

In summary, the group-based exercise program was associated with significant improvements in both depressive symptoms and BMI at the 12-week follow-up compared to baseline. While a significant overall variation in waist circumference was detected, pairwise differences did not reach statistical significance after adjustment for multiple comparisons.

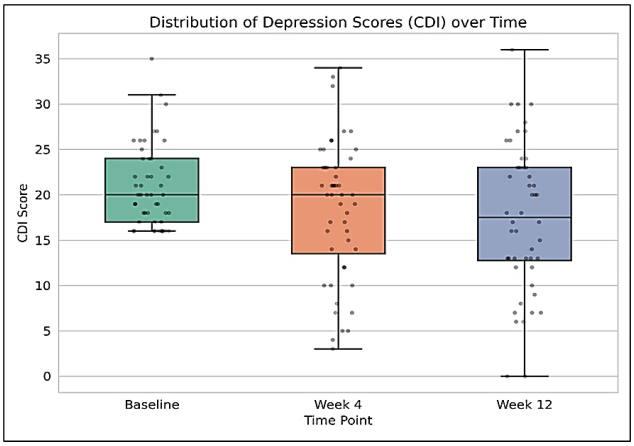

Figure 2: Trends in depressive symptoms (CDI scores) at baseline, week 4, and week 12.

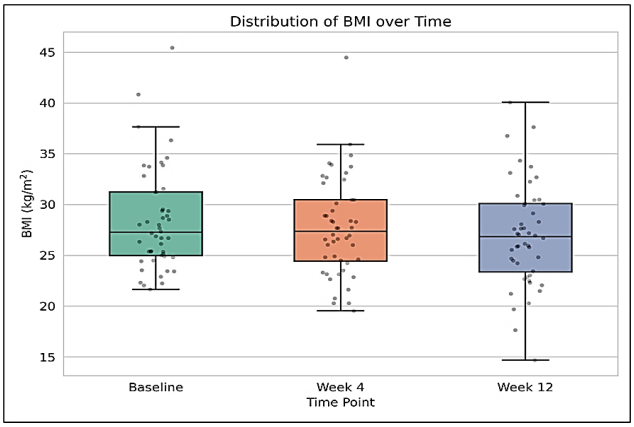

Figure 3: Longitudinal changes in BMI over the 12-week study period.

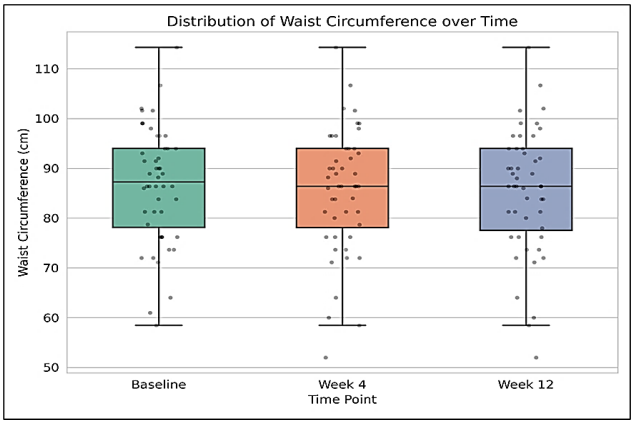

Figure 4: Trends in waist circumference across the three time points (baseline, week 4, and week 12).

Table 1: Baseline characteristics of the participants (n=48).

Characteristics	N (%)
Age (in years), median (IQR)	13.00 (13.00-14.00)
Sex	
Male	24 (50.0)
Female	24 (50.0)
Anthropometric measurements	
Weight (kg), median (IQR)	75.00 (65.00-80.00)
Height (m), mean±SD	1.63±0.07
BMI (kg/m²), median (IQR)	27.26 (24.97-31.23)
Waist circumference (cm), mean±SD	86.59±11.74
Clinical characteristics	
CDI score (Depression), median (IQR)	20.00 (17.00-24.00)
Underlying diseases	
No	40 (83.3)
Yes	8 (16.7)
Family and social factors	
Parental marital status	
Living together	35 (72.9)
Separated/divorced	13 (27.1)
Health behaviors	
Smoking or E-cigarette use	
No	45 (93.8)
Yes	3 (6.2)
Alcohol consumption	
No	40 (83.3)
Yes	8 (16.7)
Sleep sufficiency	
Sufficient	39 (81.2)
Insufficient	9 (18.8)
Physical activity and motivation	
Exercise prior to the program	
Yes	26 (54.2)
No	22 (45.8)
Motivation for exercise	
Has motivation	26 (54.2)
No motivation	22 (45.8)
Perceived barriers to exercise	
No barriers	36 (75.0)
Has barriers	12 (25.0)
Inspiration for exercise	
Has inspiration	25 (52.1)
No inspiration	23 (47.9)

*SD=Standard deviation, IQR=Interquartile range; CDI=Children's depression inventory. Continuous variables are presented as mean±SD for normally distributed data and median (IQR) for non-normally distributed data. Categorical variables are presented as frequency (percentage).

Table 2: Comparison of primary and secondary outcomes across three time points, (n=48).

Variables	Baseline median (IQR)	Week4 median (IQR)	Week 12 median (IQR)	Friedman test (P value)	Post-hoc pairwise comparisons (p value)		
					Base and W4	W4 and W12	Base and W12
Primary outcome							
CDI score	20.00 (17.00-24.00)	20.00 (13.50-23.00)	17.50 (12.75-23.00)	0.203	0.103	1.000	0.016*
Secondary outcomes							
BMI (kg/m²)	27.26 (24.97-31.23)	27.36 (24.43-30.47)	26.83 (23.35-30.09)	0.004*	0.063	0.200	0.002*
Waist (cm)	87.28 (78.10-93.98)	86.36 (78.08-93.98)	86.36 (77.55- 93.98)	0.006*	0.129	0.539	0.083

*CDI=Children's depression inventory; BMI=Body mass index; IQR=Interquartile range; W4=Week 4; W12=week 12. Note: Data are presented as median (IQR).

DISCUSSION

The primary objective of this study was to evaluate the effectiveness of a group-based aerobic exercise program on depressive symptoms and nutritional status among adolescents with overweight or obesity. The salient finding is that, following a 12-week intervention period, participants exhibited a statistically significant reduction in CDI scores compared to baseline. These findings demonstrate that moderate-intensity group exercise is a highly efficacious therapeutic strategy for ameliorating depressive symptoms in this vulnerable demographic.

Regarding the primary outcome, our results corroborate and extend the findings of Jarbin et al and Petty et al who reported that structured exercise interventions significantly mitigate psychopathological symptoms in youth.[9,10] While a previous study by Daley et al did not observe a significant reduction in CDI scores among a general cohort of adolescents with obesity, they hypothesized that exercise would yield greater psychological benefits if targeted specifically at individuals with pre-existing depressive symptoms.[8]

Our study provides empirical validation for this hypothesis; by utilizing an inclusion criterion of mild-to-moderate depression (CDI≥16), we observed a pronounced therapeutic effect. Mechanistically, this improvement can be attributed not only to exercise-induced neurobiological changes, such as the upregulation of endorphins and brain-derived neurotrophic factor (BDNF), but also to the psychosocial benefits of the group-based format. Supervised peer-group activities foster social connectedness and enhance self-esteem, which are critical protective factors against adolescent depression.

For the secondary anthropometric outcomes, the intervention resulted in a significant reduction in BMI at week 12. This aligns with established evidence demonstrating the efficacy of aerobic exercise in increasing energy expenditure and reducing total body adiposity in pediatric populations.[10] Conversely, while a decreasing trend in waist circumference was observed, it did not reach statistical significance. This parameter-specific discrepancy is consistent with broader literature indicating that the significant mobilization of visceral adipose tissue typically requires interventions of longer duration or higher intensity than what is necessary for overall BMI reduction.

Therefore, while the current 4-week active intervention with a 12-week follow-up was sufficient to improve mood and overall BMI, a more extended program may be requisite for substantial central adiposity reduction.

Beyond physiological mechanisms, psychosocial factors likely played a pivotal role in the observed mental health improvements. The "group-based" nature of the intervention, conducted under professional supervision, likely facilitated social interaction, fostered a sense of belonging, and enhanced self-esteem. These are critical protective factors against depression and social isolation in adolescence. The presence of peers and instructors provided a social support system, which may have promoted better adherence and emotional well-being compared to solitary exercise.

Several limitations of this study warrant consideration. First, the single-center design with a limited sample size may restrict the generalizability of the findings to broader adolescent populations. Second, the 12-week follow-up period may be insufficient to assess the long-term sustainability of mental health improvements and behavioral modifications. Finally, the absence of a control group (single-arm design) precludes the ability to definitively rule out confounding factors such as natural maturation or regression to the mean.

In conclusion, this study provides empirical evidence supporting the implementation of school-based, supervised group exercise programs as an effective adjunctive intervention for adolescents with concurrent obesity and depression. Integrating such programs into school health systems and primary care networks represents a promising strategy for the sustainable promotion of adolescent physical and mental well-being.

Strengths

The study utilizes a quasi-experimental repeated-measures design to target a high-risk adolescent population in Thailand, effectively filling a gap in local empirical evidence. Key strengths include the use of standardized assessment tools (CDI and objective anthropometrics) and the implementation of the intervention within a real-world school setting, which enhances both the reliability of the trend analysis and the external validity regarding scalability. Furthermore, by establishing a link between physical activity and mental health outcomes, these findings provide a practical foundation for developing integrated health promotion policies across educational and public health sectors.

Limitations

Several limitations warrant consideration when interpreting the results. The single-arm, quasi-experimental design without a control group precludes the complete elimination of confounding factors, such as external lifestyle changes. Generalizability is limited by the recruitment from a single school, and the sample size, while sufficient for the primary outcome, may have been underpowered to detect significant differences in secondary anthropometric indices like waist circumference. Additionally, the 12-week duration may be insufficient to capture long-term physiological adaptations, and the reliance on self-reported psychological measures introduces the potential for response bias.

CONCLUSION

This study evaluated the effectiveness of a moderate-intensity group-based aerobic exercise program on depressive symptoms and physical parameters in adolescents aged 12-15 years with overweight or obesity and concomitant depression (CDI≥16). The findings demonstrate that adhering to a 12-week regimen (3 sessions/week) resulted in a statistically significant reduction in depressive symptom severity, accompanied by significant improvements in BMI and observable reductions in waist circumference. These results underscore the dual benefits of exercise on both mental and physical health.

Furthermore, the "group-based" nature of the intervention likely facilitated motivation, adherence, and a sense of belonging, which positively influenced participants' emotional well-being and health behaviors. Consequently, this study confirms that supervised group exercise serves as an effective adjunctive intervention for managing adolescents with co-occurring obesity and depression. These findings support the integration of such programs into school health initiatives and public health strategies to sustainably prevent and mitigate depression and obesity among vulnerable youth populations.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Kaewumpa P, Phithakwongrojn K, Bosittipichet T, Leesri T. Effects of a school-based group exercise program on depressive symptoms in adolescents with overweight and obesity: a quasi-experimental study. Int J Community Med Public Health 2026;13:1621-8.