JURNAL KEDOKTERAN DIPONEGORO
(*DIPONEGORO MEDICAL JOURNAL*)
Online : http://ejournal3.undip.ac.id/index.php/medico
E-ISSN : 2540-8844
DOI : 10.14710/dmj.v15i6.55218
JKD (DMJ), Volume 15, Number 6, November 2026 : 600-608

HIGH-INTENSITY INTERVAL TRAINING EFFECTS ON SLEEP, ANXIETY AND QUALITY OF LIFE IN OBESE AND OVERWEIGHT ADOLESCENTS

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Keywords:
anxiety,
High-Intensity Interval Training,
obesity,
overweight,
sleep quality,
quality of life

Received: 13 January 2026
Revised: 2 March 2026
Accepted: 2 March 2026
Available online: 01 November 2026

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ABSTRACT

Background: It is estimated that more than 7 million Indonesians aged 5–19 years were living with obesity. The rise of obesity is also highly associated with increasing sleep disturbance, psychological distress, and reduced quality of life. High-Intensity Interval Training (HIIT) is a time-efficient exercise strategy that may improve these outcomes. **Objective:** To analyze the effects of twelve weeks HIIT program on sleep quality, depression, anxiety, stress symptoms, and quality of life among overweight and obese adolescents in Indonesia. **Methods:** Quasi-experimental pre–post study compared a HIIT group with a control group. Participants were recruited from two senior high schools in Semarang. HIIT was performed three times weekly for twelve weeks. Sleep quality was assessed using PSQI, psychological symptoms with DASS-21, and quality of life with the Indonesian WHOQOL-BREF. Wilcoxon and Mann–Whitney tests were used ($p<0.05$). **Results:** The HIIT group showed improved sleep quality with lower PSQI scores (median 5 to 3; $p<0.001$), while the control group was indifferent. DASS-21 subscales improved in the HIIT group, with reductions in depression ($p=0.005$), anxiety ($p<0.001$), and stress ($p=0.006$); post-intervention scores favored HIIT for depression ($p=0.003$), anxiety ($p<0.001$), and stress ($p=0.026$). At Indonesian WHOQOL-BREF, HIIT increased the psychological domain ($p=0.002$), social relationships domain ($p=0.015$), and the environmental domain ($p=0.011$), but not the physical domain ($p>0.05$). Post-intervention, between-group differences were significant for psychological ($p<0.001$) and environmental domains ($p=0.021$), but not for social relationships. **Conclusions:** Twelve weeks HIIT program improved sleep quality, reduced depression, anxiety, stress symptoms and enhanced quality-of-life domains, supporting HIIT as school-based option for overweight and obese adolescents.

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BACKGROUND

The global prevalence of overweight and obesity has increased sharply. In 2022, the World Health Organization (WHO) estimated that more than 2.5 billion adults were overweight, including over 890 million with obesity, about double the level in 1990. This rise also affects children and adolescents worldwide.[1] In Indonesia, the World Obesity Federation estimated that over 7.3 million children aged 5–19 years were living with obesity in 2019, ranking Indonesia fourth globally.[2] Overweight and obesity are multifactorial, shaped by individual factors, family environment, and broader determinants such as public policy. The COVID-19 pandemic further worsened youth risk behaviors, including reduced physical activity, increased screen time, unhealthy diets, and higher stress.[3]

Adolescent obesity has substantial medical and psychosocial consequences. Youth with obesity are more vulnerable to stigma, low self-esteem, poorer academic performance, anxiety, depression, and social isolation.[4,5] Sleep problems are also more common; shorter sleep duration is inversely associated with adiposity.[4] Poor sleep quality further exacerbates metabolic dysregulation, emotional instability, and cognitive functioning during this

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critical developmental period. These physical and psychosocial burdens contribute to reduced health-related quality of life.[6] Therefore, interventions should address both physical and psychological dimensions.

Physical activity is a cornerstone of adolescent obesity management.[7] Higher activity levels are associated with lower obesity risk and fewer cardiometabolic complications.[8] WHO-based recommendations advise at least 60 minutes of moderate-to-vigorous activity daily for ages 5–17 years.[9] Previous research has studied High-Intensity Interval Training (HIIT) as a time-efficient approach for enhancing physical fitness and body composition in overweight and obese youth.[10,11] Growing evidence also suggests potential benefits for sleep quality, anxiety, and quality of life, particularly in sedentary individuals.[12]

Given the increasing burden and multidimensional impacts of adolescent obesity, this study examines whether HIIT improves sleep quality, anxiety levels, and quality of life in overweight and obese adolescents by comparing outcomes before and after intervention.

MATERIAL AND METHODS

This quasi-experimental study was conducted at Don Bosko Senior High School and YSKI Senior High School in Semarang. Adolescents aged 16–19 years with overweight/obesity based on BMI criteria were recruited using purposive sampling and allocated into two groups: a HIIT group and a control group, with targeted sample of 104 participants.

The independent variable was participation in twelve weeks HIIT program, while outcomes included sleep quality (Pittsburgh Sleep Quality Index/ PSQI); depression, anxiety, stress symptoms (Depression Anxiety Stress Scale/ DASS-21) and quality of life (Indonesian WHOQOL-BREF). Eligibility required adolescents with BMI >23 kg/m², adequate cognitive status, sufficient exercise capacity, low cardiovascular risk and readiness for exercise, acceptable fasting glucose and blood pressure, low habitual physical activity, and parental consent. Exclusion criteria included significant cardiovascular disease with low exercise tolerance, cancer history/therapy, trauma or musculoskeletal conditions limiting exercise. Dropout criteria included missing three consecutive sessions, low session attendance, absence during assessments, or withdrawal.

All participants completed baseline PSQI, DASS-21, and Indonesian WHOQOL-BREF assessments, followed by post-intervention reassessment. Target heart rate was calculated individually. The HIIT program was performed at school facilities three times weekly for twelve weeks, supervised by a trainer, with pre-session vital checks and monitoring for adverse signs; sessions were stopped if safety thresholds were exceeded or concerning symptoms occurred. The control group received no exercise intervention.

Sample size was calculated for between-group comparisons with adjustment for dropout. Data analysis included normality testing (Shapiro–Wilk) and nonparametric comparisons between groups (Mann–Whitney) and within groups (Wilcoxon), with significance set at $p<0.05$. Ethical approval was obtained from the Faculty of Medicine, Diponegoro University; parental written informed consent and participant confidentiality were ensured.

RESULTS

A total of 104 participants were initially recruited, consisting of 52 students in the HIIT group, and 52 students in the control group. Prior to the intervention period, both groups received health education. Ten participants dropped out (five in each group) after missing three consecutive sessions due to illness or other reasons. The final analysis included 94 participants (47 per group).

The baseline characteristics (Table 1) did not differ significantly in terms of age, body mass index (BMI), or hip circumference within either group. However, higher median significant differences were observed in waist circumference and waist–hip ratio at the HIIT group.

Table 1. Baseline Characteristics

Variable	HIIT (n=47)	Control (n=47)	p
Age (years)	16.32 ± 1.05	16.49 ± 0.95	0.502‡
BMI (kg/m²)	31.52 ± 6.48	28.94 ± 4.77	1.000‡
Waist circumference (cm)	98.68 ± 15.75	87.17 ± 10.89	<0.001‡
Hip circumference (cm)	103.04 ± 14.63	98.43 ± 12.31	0.115‡

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Variable	HIIT (n=47)	Control (n=47)	p
Waist-hip ratio	0.96 ± 0.06	0.89 ± 0.05	<0.001‡

‡Mann-Whitney test
BMI=Body Mass Index

Quality of Life

The results regarding quality of life outcome (Table 2) indicated a significant difference in physical domain scores between the HIIT and control groups at baseline (p<0.05), suggesting that the two groups were not comparable prior to the intervention. However, post-intervention comparisons revealed no statistically significant differences between groups (p>0.05). Within-group analyses showed that physical domain scores did not change significantly from pre- to post-intervention in the HIIT group, whereas a significant change was observed in the control group (p<0.001).

In the psychological, social, and environmental domains, within-group analysis showed significant improvements in only the HIIT group (p=0.002, p=0.015, and p=0.011, respectively). Between-group comparisons of post-intervention results indicated significant differences only in the psychological and environmental domains (p<0.001 and p=0.021, respectively), while the social domain did not show a significant difference between the two groups (p=0.054).

These results imply that while the HIIT program did not substantially improve physical quality of life, it contributed positively to psychological and well-being. Improvements in the social domain were observed only within the HIIT group, but not strong enough to produce significant differences compared with the control group.

Table 2. Comparison of Four Quality-of-Life Domains using Indonesian WHOQOL-BREF

Variable	Pre			Post			Within-group (p)	
	HIIT n (%)	Control n (%)	p	HIIT n (%)	Control n (%)	p	HIIT	Control
Physical domain								
Good	17 (36.2)	2 (4.3)	<0.001‡*	21 (44.7)	10 (21.3)	0.037‡*	0.297†	<0.001†*
Fairly good	23 (489)	18 (38.3)		20 (42.6)	29 (61.7)			
Fairly poor	6 (12.8)	25 (53.2)		5 (10.6)	7 (149)			
Poor	1 (2.1)	2 (4.3)		1 (2.1)	1 (2.1)			
Psychological domain								
Good	8 (17)	5 (10.6)	0.523¶	14 (29.8)	1 (2.1)	<0.001¶*	0.002†*	0.703†
Fairly good	16 (34)	12 (25.2)		24 (51.1)	17 (36.2)			
Fairly poor	19 (40.4)	24 (51.1)		5 (10.6)	22 (46.8)			
Poor	4 (8.5)	6 (12.8)		4 (8.5)	7 (14.9)			
Social domain								
Good	4 (8.5)	5 (10.6)	0.538‡	8 (17)	2 (4.3)	0.054‡	0.015†*	0.532†
Fairly good	18 (38.3)	19 (40.4)		23 (48.9)	21 (44.7)			
Fairly poor	21 (44.7)	21 (44.7)		14 (29.8)	23 (48.9)			
Poor	4 (8.5)	2 (4.3)		2 (4.3)	1 (2.1)			
Environmental domain								
Good	8 (17)	10 (21.3)	0.402‡	11 (23.4)	7 (14.9)	0.021¶*	0.011†*	0.225†
Fairly good	27 (57.4)	28 (59.6)		34 (72.3)	29 (61.7)			
Fairly poor	11 (23.4)	9 (19.1)		2 (4.3)	10 (21.3)			
Poor	1 (2.1)	0 (0)		0 (0)	1 (2.1)			

*Significant (p<0,05); †Wilcoxon test; ‡Mann-Whitney test; ¶Pearson Chi-Square

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Anxiety Level

Paired comparisons (Wilcoxon test) showed that the HIIT group experienced a significant reduction in depressive symptoms at the HIIT group, in contrast to the control group, as shown in Table 3. Between-group comparisons (Mann–Whitney test) indicated that depression levels differed between groups at baseline and after the intervention, supporting an overall beneficial effect of HIIT on depressive symptoms despite initial group differences.

For anxiety, baseline distributions were broadly comparable between the HIIT and control groups, with no statistically significant difference at baseline. After twelve weeks period, anxiety outcomes clearly favored the HIIT group compared with the control group. Within-group analysis confirmed a significant reduction in anxiety symptoms in the HIIT group. Post-intervention between-group testing also demonstrated a significant difference, indicating superior anxiety outcomes among adolescents who participated in HIIT.

A similar pattern was observed for stress. At baseline, stress levels did not differ significantly between groups. Following the intervention, the HIIT group showed a clear improvement. Statistical testing supported this shift: stress decreased significantly within the HIIT group, while the control group did not. Post-intervention comparisons further indicated better stress outcomes in the HIIT group compared with controls.

Overall, these findings suggest that a structured HIIT program is associated with improvements in psychological outcomes—particularly anxiety and stress—and contributes to reductions in depressive symptoms, compared with no HIIT.

Table 3. Differences in Depression, Anxiety, and Stress Levels using DASS-21

Severity category	Pre			Post			Within-group (p)	
	HIIT n (%)	Control n (%)	p	HIIT n (%)	Control n (%)	p	HIIT	Control
Depression								
Normal	26 (55.3)	13 (27.7)	0.005‡*	30 (63.8)	18 (38.3)	0.003‡*	0.005†*	0.068†
Mild	9 (19.1)	11 (23.4)		9 (19.1)	8 (17.0)			
Moderate	8 (17.0)	14 (29.8)		7 (14.9)	14 (29.8)			
Severe	3 (6.4)	6 (12.8)		1 (2.1)	4 (8.5)			
Very severe	1 (2.1)	3 (6.4)		0 (0.0)	3 (6.4)			
Anxiety								
Normal	20 (42.6)	14 (29.8)	0.053‡	29 (61.7)	14 (29.8)	<0.001‡*	<0.001†*	0.079†
Mild	5 (10.6)	2 (4.3)		11 (23.4)	3 (6.4)			
Moderate	12 (25.5)	11 (23.4)		6 (12.8)	17 (36.2)			
Severe	2 (4.3)	7 (14.9)		0 (0.0)	5 (10.6)			
Very severe	8 (17.0)	13 (27.7)		1 (2.1)	8 (17.0)			
Stress								
Normal	34 (72.3)	29 (61.7)	0.235‡	40 (85.1)	31 (66.0)	0.026‡*	0.006†*	0.279†
Mild	5 (10.6)	5 (10.6)		1 (2.1)	3 (6.4)			
Moderate	6 (10.6)	8 (17.0)		6 (12.8)	9 (19.1)			
Severe	2 (4.3)	3 (6.4)		0 (0.0)	3 (6.4)			
Very severe	1 (2.1)	2 (4.3)		0 (0.0)	1 (2.1)			

*Significant ($p<0.05$); †Wilcoxon test; ‡Mann–Whitney test

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Sleep Quality

After twelve weeks intervention, the HIIT group showed a significant improvement in sleep quality (Table 4). Within-group analysis indicated a significant reduction in PSQI scores in the HIIT group ($p<0.001$), whereas no significant change was observed in the control group ($p=0.973$).

Overall, these findings demonstrate that the HIIT program effectively enhanced sleep quality among overweight and obese adolescents, while the group without HIIT showed no meaningful improvement.

Table 4. Differences in PSQI assessment

PSQI	HIIT Median (min-max)	Control Median (min-max)	p
Pre	5 (1 – 11)	5 (1 – 13)	0,261‡
Post	3 (0 – 9)	5 (2 – 12)	<0,001‡*
p	<0,001†*	0,973†	
Delta	-2 (-8 – 2)	0 (-10 – 5)	0,001‡*

*Significant ($p<0.05$); †Wilcoxon test;
‡Mann–Whitney test

DISCUSSION

Quality of Life

This study shows that twelve weeks HIIT program significantly improved the psychological, social, and environmental domains of quality of life (Indonesian WHOQOL-BREF) in overweight and obese adolescents, supporting evidence that high-intensity activity can provide important psychosocial benefits beyond physiological effects.

In contrast, HIIT did not significantly improve the physical quality-of-life domain. A meaningful baseline difference between groups suggests possible selection bias that could have attenuated the observed intervention effect. Notably, the control group improved from pre- to post-test, which may reflect non-intervention influences such as behavioral changes related to study participation (Hawthorne effect). These findings align with meta-analytic evidence that HIIT in obese adolescents consistently improves physiological outcomes (e.g., body composition and cardiorespiratory fitness), but does not uniformly translate into better perceived quality of life, particularly in the physical domain.[13]

Improvements in the psychological domain may be explained by exercise-related neurobiological effects, including increased release of endorphins, dopamine, serotonin, and norepinephrine, which contribute to mood regulation and reductions in stress and depressive symptoms. HIIT may also enhance self-efficacy and perceived accomplishment, thereby strengthening psychological well-being.[14] Prior studies similarly report beneficial effects of HIIT on psychological outcomes, although effect size may vary by training duration and intensity.[15]

Group-based HIIT may additionally improve the social domain by fostering peer interaction, social support, and belonging.[16] Multidisciplinary and group-oriented interventions have been shown to enhance social relationships and satisfaction in obese adolescents.[17] However, the lack of significant between-group differences in social outcomes in this study may relate to the intervention duration, individual variation in social perception, and contextual factors such as family support and school environment.[18]

Feasibility trial by Andersen et al. found that integrating HIIT into lifestyle programs produced short-term improvements in HRQOL, particularly emotional well-being and self-confidence, reinforcing the potential affective benefits of HIIT.[19]

Anxiety Levels

HIIT may reduce anxiety via improved cardiorespiratory fitness and autonomic regulation (including increased heart rate variability), endorphin-mediated mood enhancement, potential cortisol modulation, and reduction of inflammatory markers (e.g., C-reactive protein). Psychologically, completing challenging intervals may increase self-efficacy and provide attentional distraction from anxiety-provoking stimuli, improving cognitive and emotional functioning.[20]

In this study, anxiety symptoms decreased significantly after the HIIT protocol, while the control group showed no meaningful change. These results are consistent with evidence that physical activity is linked to lower anxiety in adolescents.[21] That exercise can acutely improve mood and reduce negative affect.[22] Online and combined approaches (HIIT plus health education) have also been reported to improve physical activity, mental health, and cognitive

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outcomes.[23] Euro biological studies further suggest that aerobic exercise may enhance brain connectivity and emotional regulation, particularly in individuals with higher anxiety.[24,25]

Depressive symptoms also improved significantly in the HIIT group only. This aligns with findings that higher-intensity physical activity is associated with lower depression and anxiety.[26] although other studies suggest depressive symptoms may not always respond to regular activity in adolescents.[27]

For stress, this study did not demonstrate significant improvement in either group. Similar null findings have been reported after HIIT in young adults.[28] High-intensity exercise may provoke stronger physiological stress responses in some participants, suggesting that moderate-intensity exercise may be more suitable for beginners or for sustained adherence.

Sleep Quality

HIIT program showed significant improvement within the intervention group in sleep quality (lower PSQI), while the control group showed no meaningful change. Baseline PSQI did not differ between groups, but a significant between-group difference appeared after the intervention, favoring HIIT.

Evidence supports a strong link between obesity and poorer sleep in adolescents: a study reported higher PSQI scores in adolescents with obesity and a moderate correlation between BMI SDS and PSQI, indicating worse sleep with higher adiposity.[29] A systematic review and meta-analysis in adults with obesity also found HIIT significantly reduced PSQI scores, suggesting HIIT can improve sleep disturbances in obesity, potentially via better autonomic regulation and reduced physiological stress.[30] In adolescents, a randomized controlled trial among senior high school boys showed that both HIIT and traditional exercise significantly reduced PSQI compared with controls, supporting the role of structured training in improving sleep quality.[31]

Mechanistically, vigorous exercise may enhance sleep through increased physiological fatigue and recovery processes, and HIIT may reduce inflammation and oxidative stress while improving insulin sensitivity, factors that can indirectly improve sleep.[30] HIIT may also improves circadian alignment and facilitating sleep initiation and efficiency.[30]

CONCLUSION

This quasi-experimental study showed that twelve weeks HIIT was effective in improving several key psychosocial outcomes among overweight and obese adolescents. HIIT significantly enhanced sleep quality, as evidenced by greater reductions in PSQI scores in the intervention group compared with the control group. The intervention also led to meaningful decreases in anxiety and depression levels, and to significant improvements in psychological and environmental domains of quality of life, while social quality of life improved within the HIIT group but did not differ significantly between groups.

In contrast, the physical domain of quality of life did not show a significant improvement in the HIIT group compared with controls, a finding that may be partly explained by baseline imbalance between groups. Overall, these results support the role of HIIT as a feasible and beneficial component of lifestyle interventions aimed at improving mental health, sleep quality, and several aspects of quality of life in overweight and obese adolescents. Future studies with longer follow-up, larger samples, and more balanced baseline characteristics are warranted to clarify the long-term impact of HIIT on physical quality of life and cardiometabolic outcomes in this population.

ETHICAL APPROVAL

The research was conducted after obtaining ethical clearance no.551/EC/KEPK/FK-UNDIP/X/2024 from the Health Research Ethics Commission (KEPK) of the Faculty of Medicine at Diponegoro University.

CONFLICT OF INTEREST

The authors declare no potential conflict of interest with respect to the research, authorship, and/or publication of this article.

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FUNDING

This study was supported by a research grant 2024 from Faculty of Medicine, Diponegoro University, Indonesia.

AUTHOR CONTRIBUTION

The authors confirm contribution to the article areas as follows: Conceptualization, Dayita Sukma Destanta, Avissia Zivanna, Elisha Jethro Solaiman, Erna Setiawati and Tanti Ajoe Kesoema; methodology, Dayita Sukma Destanta, Avissia Zivanna and Elisha Jethro Solaiman; software, Dayita Sukma Destanta, Avissia Zivanna and Elisha Jethro Solaiman; validation, Dayita Sukma Destanta, Avissia Zivanna, Elisha Jethro Solaiman, Erna Setiawati and Tanti Ajoe Kesoema; formal analysis, Dayita Sukma Destanta, Avissia Zivanna, Elisha Jethro Solaiman, Erna Setiawati and Tanti Ajoe Kesoema; investigation, Dayita Sukma Destanta, Avissia Zivanna, Elisha Jethro Solaiman, Erna Setiawati and Tanti Ajoe Kesoema; resources, Dayita Sukma Destanta, Avissia Zivanna and Elisha Jethro Solaiman; data curation, Dayita Sukma Destanta, Avissia Zivanna, Elisha Jethro Solaiman, Erna Setiawati and Tanti Ajoe Kesoema; writing—original draft preparation, Dayita Sukma Destanta, Avissia Zivanna and Elisha Jethro Solaiman; writing—review and editing, Dayita Sukma Destanta, Avissia Zivanna, Elisha Jethro Solaiman, Erna Setiawati and Tanti Ajoe Kesoema; visualization, Dayita Sukma Destanta, Avissia Zivanna and Elisha Jethro Solaiman; supervision, Erna Setiawati and Tanti Ajoe Kesoema; project administration, Erna Setiawati and Tanti Ajoe Kesoema; funding acquisition, a research grant 2024 from Faculty of Medicine, Diponegoro University, Indonesia

ACKNOWLEDGMENTS

The researchers would like to thank all participants who kindly participated in this study. This research was supported by Don Bosko Senior High School, YSKI Senior High School, and the Department of Physical Medicine and Rehabilitation, Faculty of Medicine, Diponegoro University.

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JURNAL KEDOKTERAN DIPONEGORO
(*DIPONEGORO MEDICAL JOURNAL*)
Online : http://ejournal3.undip.ac.id/index.php/medico
E-ISSN : 2540-8844
DOI : 10.14710/dmj.v15i6.55218
JKD (DMJ), Volume 15, Number 6, November 2026 : 600-608

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