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Effects of moderate-intensity combination exercise on increase adiponectin levels, muscle mass, and decrease fat mass in obese women

Efectos del ejercicio combinado de intensidad moderada sobre el aumento de los niveles de adiponectina, la masa muscular y la disminución de la masa grasa en mujeres obesas

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Abstract. Obesity is reported to be strongly associated with low levels of adiponectin, which may be involved in metabolic syndrome, insulin resistance, cardiovascular disease, hypertension, and cancer cell proliferation. Meanwhile, physical exercise has been reported to increase adiponectin levels and decrease insulin resistance in obese individuals. Therefore, this study aimed to prove the effects of four weeks of moderate-intensity combination exercise (aerobic and resistance) on increasing adiponectin levels, skeletal muscle mass (SMM), and decreasing fat mass (FM) in obese women. A total of 14 obese adolescent women aged 20-24 years with a body mass index (BMI) of 27.5-36.5 kg/m^2 (based on Asia-Pacific BMI classification) were selected as research subjects and divided into two intervention groups: control (CON) and moderate-intensity combination exercise (MCE) groups. The ELISA kit method was used to analyze pre- and post-exercise adiponectin levels, while the mBCA 554 seca was used to measure BMI, FM, and SMM. Statistical analysis was performed using an independent samples t-test with a 5% significance level. The data showed Δ-BMI between CON and MCE (0.54±0.99 vs -1.31±0.19 kg/m2; p = 0.001), Δ-FM (1.56±3.89 vs -3.60±1.16 kg; p = 0.006), Δ-SMM (-0.85±1.91 vs 3.61±0.74 kg; p = 0.001), Δ-Adiponectin (0.55±2.39 vs 15.45±6.21 ng/mL; p = 0.001). The results demonstrate that a 4-week moderate-intensity combination exercise intervention effectively increases adiponectin levels and skeletal muscle mass and reduces body mass index and fat mass in obese women.
Keywords: Obesity, combination exercise, adiponectin levels, body composition

Resumen. Se informa que la obesidad está fuertemente asociada con niveles bajos de adiponectina, que puede estar implicada en el síndrome metabólico, la resistencia a la insulina, las enfermedades cardiovasculares, la hipertensión y la proliferación de células cancerosas. Mientras tanto, se ha informado que el ejercicio físico aumenta los niveles de adiponectina y disminuye la resistencia a la insulina en personas obesas. Por lo tanto, este estudio tuvo como objetivo probar los efectos de cuatro semanas de ejercicio combinado de intensidad moderada (aeróbico y de resistencia) sobre el aumento de los niveles de adiponectina, la masa del músculo esquelético (SMM) y la disminución de la masa grasa (FM) en mujeres obesas. Se seleccionaron como sujetos de investigación un total de 14 mujeres adolescentes obesas de entre 20 y 24 años con un índice de masa corporal (IMC) de 27.5 a 36.5 kg/m^2 (según la clasificación del IMC de Asia y el Pacífico) y se dividieron en dos grupos de intervención: control (CON) y grupos de ejercicio combinado de intensidad moderada (MCE). Se utilizó el método del kit ELISA para analizar los niveles de adiponectina antes y después del ejercicio, mientras que el mBCA 554 seca se utilizó para medir el IMC, la FM y el SMM. El análisis estadístico se realizó mediante una prueba t para muestras independientes con un nivel de significancia del 5%. Los datos mostraron Δ-IMC entre CON y MCE (0.54±0.99 vs -1.31±0.19 kg/m^2; p = 0.001), Δ-FM (1.56±3.89 vs -3.60±1.16 kg; p = 0.006), Δ-SMM (-0.85±1.91 vs 3.61±0.74 kg; p = 0.001), Δ-Adiponectina (0.55±2.39 vs 15.45±6.21 ng/mL; p = 0.001). Los resultados demuestran que una intervención de ejercicio combinado de intensidad moderada durante 4 semanas aumenta eficazmente los niveles de adiponectina y la masa del músculo esquelético y reduce el índice de masa corporal y la masa grasa en mujeres obesas.
Palabras clave: Obesidad, ejercicio combinado, niveles de adiponectina, composición corporal

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Introduction

Obesity and diabetes are growing health problems that affect more than a billion people across the world (Bailey, et al., 2024). Obesity is defined as a condition of excessive accumulation of adipose tissue and is associated with the risk of type 2 diabetes mellitus (T2DM) and cardiovascular disease (Gonzales-Muniesa et al., 2017). Obesity will cause a third of the rise in diabetes cases by 2030, affecting 9.5% of adults (Grant, et al., 2021). In addition, it is well-known that high-fat accumulation is also a major cause of cardiovascular disease in obesity (Alebna et al., 2024). Previous studies have shown that the incidence of obesity is strongly correlated with low adiponectin levels (<2 μg/mL) or hypoadiponectinemia (Robinson et al., 2011). Adiponectin is a type of adipokine protein secreted exclusively by adipocytes and plays a role in insulin sensitivity and vascular protection (Robinson et al., 2011). Adiponectin is a protein from fat cells that helps balance blood sugar, fats, and insulin and protects from inflammation, scarring, and oxidative stress (Nguyen, et al., 2020; Rejeki et al., 2023). Adiponectin plays a vital role in obesity-related diseases such as T2DM and atherosclerosis; thus, low levels of adiponectin in obese individuals may be implicated in the occurrence of metabolic syndrome, insulin resistance, cardiovascular disease, hypertension, and cancer cell proliferation (Parida et al., 2019; Yamauchi & Kadowaki, 2013).

In general, obesity can be influenced by an unhealthy lifestyle, such as low physical activity and overeating (Pranoto et al., 2023). Recent studies have suggested that exercise effectively increases adiponectin levels and reduces insulin resistance in obese and diabetic individuals (Zaidi et al., 2021; Rejeki et al., 2023). Research by Akbarpour

(2013) on aerobic exercise for 30 minutes, frequency 3x/week for 12 weeks at an intensity of 75 and 85% of maximum heart rate showed an increase in adiponectin levels by 11.49% compared to the control group in obese male subjects. A study by Park et al. (2019) also reported a significant increase in adiponectin levels in postmenopausal obese women after a 12-week resistance training intervention. A 12-week combination of aerobic and resistance exercise was also reported to increase adiponectin levels and subsequently decrease insulin resistance in obese adolescent women (Bharath et al., 2018). So, chronic combination exercise can significantly increase adipokine levels including adiponectin (Jiménez-Martínez, et al., 2023). However, a study by Jeon et al. (2013) reported a different finding that 12 weeks of combined exercise did not cause changes in adiponectin levels in overweight and obese children. Based on previous studies, there is still uncertainty in the research results on the effects of combined exercise on changes in adiponectin levels in obese women. Therefore, this study aims to demonstrate the effects of moderate-intensity combined exercise on increasing adiponectin levels muscle mass, and decreasing fat mass in obese women.

Materials and Methods

Study design

This study used a true experimental approach with a pretest-posttest control group design. A total of 14 obese adolescent women aged 20-24 years, with body mass index (BMI) of 27.5-36.5 kg/m^2 (based on Asia-Pacific BMI classification), were selected as the research subjects. The subjects were divided into the control group (CG; n=7) and moderate-intensity combination exercise (MCE; n=7). Subjects participating in this study had no history of chronic diseases, smoking, and alcohol consumption. Subjects received verbal and written information about the study and consciously filled out and signed the informed consent. The procedures applied in this study were approved by the Health Research Ethics Commission of the Faculty of Medicine, Universitas Airlangga, Surabaya, Indonesia, with registration number 18/EC/KEPK/FKUA/2022.

Intervention protocol

The MCE program was implemented and supervised by professional staff from Atlas Sports Club Malang, Indonesia. MCE is performed by combining aerobic exercise (running on a treadmill at an intensity of 60-70% HR_{max} for 45 minutes) with resistance exercise (exercise at an intensity of 60-70% 1-RM for six sets of 15 repetitions with an active rest between sets of 30 seconds). Warm-up and cool-down were performed for 5 minutes each at an intensity of 50% HR_{max} by walking on a treadmill. The exercise was performed with a frequency of 3x / week (Monday, Wednesday, Friday) for four weeks. The intervention was performed at 07.00-09.00 Western Indonesian Time (WIB). Heart rate was monitored during exercise using a polar heart rate monitor (Polar H10 Heart Rate Sensor, Inc., USA) (Pranoto et al., 2024). The research environment used had a room temperature of 26 ± 1°C and a room humidity of 50-70% (Sari et al., 2024).

Data collection

Data were collected by measuring BMI, FM, and SMM between pre- and post-exercise using the seca mBCA (Seca mBCA 554, 22089 Hamburg, Germany). Blood samples were taken twice, 30 minutes before the intervention (0 weeks) and 24 hours after the intervention (4 weeks). Subjects were instructed to fast overnight for 10-12 hours before each blood sampling. Adiponectin levels were analyzed using an enzyme-linked immunosorbent assay (ELISA) kit (REF. CAN-APN-5000; DBC, Inc. London, Ontario, Canada).

Statistical analysis

The data analysis in this study used descriptive tests, normality tests with Shapiro-Wilk, different tests with paired samples t-test, and independent samples t-test. Pearson's product-moment correlation test was used to analyze the correlation between variables. A significance level of 5% was used for statistical analysis. The data is presented as Mean ± SD. The statistical analysis was conducted using SPSS version 21 software (IBM SPSS Inc., Chicago, IL, USA).

Results

The findings of this study reported that there were no differences in the characteristics of the research subjects between the control group (CON) and moderate-intensity combined exercise (MCE) ($p \geq 0.05$), with more detailed data seen in Table 1. The results of the analysis of adiponectin, BMI, FM, and SMM levels before and after exercise in each group are shown in Figure 1. The comparison of adiponectin, BMI, FM, and SMM levels between CON and MCE is presented in Table 2, while the correlation between adiponectin levels and BMI, FM, and SMM is presented in Table 3.

Table 1.
Comparison of subject characteristics between exercise and control groups

Parameters	CON (n =7)	MCE (n =7)	p-Value
Age, yrs	22.28±1.50	21.71±1.49	0.489
Weight, kg	74.35±8.17	74.50±12.36	0.979
Height, m	1.56±0.04	1.55±0.06	0.881
BMI, kg/m^2	31.00±3.52	30.79±3.28	0.909
FM, kg	32.30±5.79	34.01±5.23	0.572
SMM, kg	18.66±1.77	19.30±3.25	0.659
WC, cm	0.92±0.09	0.90±0.05	0.576
HC, cm	1.08±0.06	1.14±0.21	0.463
WHR	0.85±0.05	0.80±0.10	0.253
SBP, mmHg	114.42±6.72	109.71±8.36	0.268
DBP, mmHg	80.14±6.84	80.57±5.91	0.902
HR, bpm	78.57±8.94	80.42±7.06	0.674
SpO_2, %	98.42±0.53	98.00±1.41	0.468
BT, °C	36.17±0.39	36.12±0.17	0.796
FBG, mg/dL	89.85±6.09	93.00±5.50	0.331
Hb, g/dL	15.70±1.64	15.97±2.14	0.796
Pre-Adiponectine, ng/mL	10.91±3.73	11.96±1.84	0.517

Description: BMI: Body mass index; FM: Fat mass; SMM: Skeletal muscle mass; WC: Waist circumference; HC: Hip circumference; WHR: Waist-to-hip ratio; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; HR: Heart rate; SpO_2: Oxygen saturation; BT: Body temperature; FBG: Fasting of blood glucose; Hb: Hemoglobin.

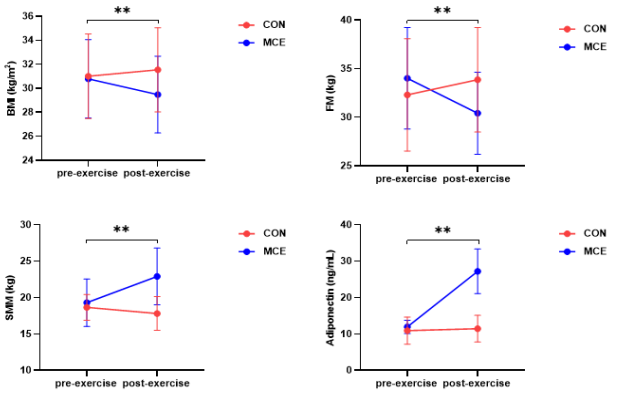

Figure 1. Comparison of BMI, FM, SMM, and adiponectin levels between pre- and post-exercise in both groups. *Significant at pre-exercise in MCE ($p \leq 0.001$).

Table 2.
Comparison of BMI, FM, SMM, and adiponectin levels between exercise and control groups

Parameters	CON (n =7)	MCE (n =7)	p-Value	Mean (95% CI)	Effect size
Post-BMI, kg/m²	31.54±3.51	29.48±3.20	0.271	-	-
Δ-BMI, kg/m²	0.54±0.99	-1.31±0.19**	0.001	0.38 (1.02 to 2.68)	2.59
Post-FM, kg	33.87±5.39	30.41±4.23	0.207	-	-
Δ-FM, kg	1.56±3.89	-3.60±1.16*	0.006	1.54 (1.82 to 8.52)	1.79
Post-SMM, kg	17.81±2.31	22.91±3.89*	0.011	1.71 (-8.83 to -1.37)	1.59
Δ-SMM, kg	-0.85±1.91	3.61±0.74**	0.001	0.77 (-6.15 to -2.78)	3.09
Post-Adiponectin, ng/mL	11.46±3.66	27.23±6.11**	0.001	2.69 (-21.64 to 9.91)	3.13
Δ-Adiponectin, ng/mL	0.55±2.39	15.45±6.21**	0.001	2.52 (-20.38 to 9.42)	3.17

*Significant at CON ($p \leq 0.05$). **Significant at CON ($p \leq 0.001$).

Table 3.
The relationship between adiponectin levels and muscle mass and fat mass

Parameters	Δ-Adiponectin, ng/mL	
	r	p-value
Δ-BMI, kg/m²	-0.736**	$p \leq 0.01$
Δ-FM, kg	-0.696**	$p \leq 0.01$
Δ-SMM, kg	0.743**	$p \leq 0.01$

*Significant with $p \leq 0.05$.

Discussion

Based on the results of this study, a 4-week moderate-intensity combination exercise intervention was effective in increasing adiponectin levels and skeletal muscle mass and decreasing body mass index and fat mass in obese females. These findings were confirmed by Lopes et al. (2016), who found an increase in serum adiponectin levels in overweight and obese adolescent girls after a 12-week combination exercise intervention. Another study also found increased adiponectin levels after a 3-month combination exercise induction in female subjects with a BMI ≥ 25 (Dieli-Conwright et al., 2018). A meta-analysis study by Becic et al. (2018) showed similar results: combined exercise (aerobic and resistance) significantly increased adiponectin levels. Moderate- to high-intensity combination exercise for 24 weeks was also shown to reduce body fat percentage and increase anti-inflammatory markers, particularly adiponectin, in obese men (Brunelli et al., 2015).

The mechanism underlying the exercise-induced increase in serum adiponectin levels is a combination of aerobic metabolism and muscle hypertrophy (Tanaka et al., 2019; Rejeki et al., 2023). Moderate-intensity aerobic exercise triggers the secretion of several lipolytic hormones and the activation of mitochondrial oxidative metabolism, which increases fat metabolism in the body as the primary source of energy (Wang et al., 2022; Muscella et al., 2020; Egan & Zierath, 2013). Meanwhile, resistance training has a hypertrophy response that induces myokine release, anti-inflammation, and activation of AMPK and PI3-kinase pathways, resulting in muscle-adipose crosstalk that underlies fat burning in the body (Khalafi et al., 2023; Leal et al., 2018; Strasser et al., 2012; Pedersen, 2011). Combination training is a solution that addresses each weakness of aerobic and resistance training. Resistance training focuses on using and hypertrophy of a few upper limb muscle groups, while aerobic training induces almost total body muscle engagement (Strasser et al., 2012). In addition, aerobic training is often associated with more significant energy expenditure, while resistance training is more associated with maintaining muscle mass, which shifts the fat mass composition (Strasser et al., 2012). This optimal fat-burning underlies the increase in circulating adiponectin levels (He, et al., 2024).

As the most significant energy reservoir and endocrine organ, adipose tissue is essential for maintaining glucose, lipid, and systemic energy homeostasis, but this metabolic function declines with age and obesity (Liu et al., 2020). Besides storing energy reserves, adipose tissue is also responsible for the secretion of several adipokines (Landecho et al., 2019, 2021). The accumulation of excess body fat in obesity increases the risk of adipose tissue dysfunction (Pellegrinelli et al., 2016; Unamuno et al., 2018; Wang et al., 2013), which leads to an imbalance in the expression and secretion of several cytokines that contribute to the development of metabolic and cardiovascular disorders (Chung & Choi, 2018). This condition has been associated with decreased adiponectin levels in obese individuals (Clemente-Suárez et al., 2023). Our results have demonstrated that moderate-intensity combination exercise performed for four weeks effectively increases muscle mass and decreases fat mass in obesity. Increasing muscle mass and decreasing fat mass may reduce the risk of adipose tissue dysfunction and restore homeostasis in obese conditions (Nguyen, 2020; Rejeki et al., 2023) characterized by elevated adiponectin levels, as demonstrated in this study. Adiponectin is widely known to have anti-inflammatory, anti-atherosclerotic, anti-apoptotic, pro-angiogenic, and insulin-sensitizing roles (Zhang et al., 2023; Fang & Judd, 2018). Increased muscle mass also improves the body's metabolic function through myokine secretion (Zhang et al., 2023).

The study measured the changes in adiponectin, a hormone that regulates glucose and insulin, and muscle and fat mass, which affect energy and metabolism, in obese patients who underwent a weight loss program. However, the study did not compare these results with normal-weight patients, which would show the impact of obesity on these factors. Also, the study did not control how much the patients exercised and ate, which could also influence these factors. Therefore, the study could not determine the exact

effects of obesity and weight loss on adiponectin, muscle, and fat mass, and further research should address these issues.

Conclusion

This study demonstrated that a combined (aerobic and resistance) moderate-intensity exercise intervention for four weeks effectively increases adiponectin levels and skeletal muscle mass and reduces body mass index and fat mass in obese women. Therefore, the results of this study can be used as recommendations for designing exercise programs to prevent and overcome obesity-related problems. By performing both aerobic and resistance exercises for a duration of four weeks, individuals who were obese can enhance their adiponectin levels, lower their body mass index and fat percentage, and augment their skeletal muscle mass. Adiponectin is a beneficial hormone that modulates glucose metabolism and inflammatory responses, which are frequently disrupted in obesity.

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Conflicts of Interest

The authors declare no conflict of interest in this work.

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