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Original Scientific Article

Long-term Endurance Training as a Modulator for Preventing Cardiovascular Disease Risk in Obese Individuals

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Abstract

Objectives. This study aimed to evaluate the long-term effects of endurance training as a modulator in the prevention of cardiovascular disease risk in obese individuals.

Materials and methods. This study used a true experimental method with a pretest-posttest control group design. Twenty-five obese women aged 20-30 years with a body fat percentage of ≥30 % were assigned to a control group (CNT) and an exercise group (EXC). The EXC group underwent an eight-week (three sessions per week) endurance training program (treadmill) lasting 40-60 minutes per session. Blood pressure (BP), mean arterial pressure (MAP), and resting heart rate (RHR) were measured using an OMRON HBP-9030 digital tensiometer and a Polar H10 heart rate sensor at the start (pre) and after eight weeks (post) of endurance training.

Results. Significant reductions in systolic blood pressure (SBP), diastolic blood pressure (DBP), MAP, and RHR were detected between the pre- and post-endurance training phases (all $p \le 0.001$). Additionally, a notable decrease in SBP, DBP, MAP, and RHR was observed between the groups (all $p \le 0.05$).

Conclusions. The findings indicate the effectiveness of an eight-week endurance training intervention, contributing to a consistent reduction in SBP, DBP, MAP, and RHR in obese women.

Keywords: blood pressure, cardiovascular disease, obesity, physical exercise.

Introduction

Obesity is a significant global health issue, with prevalence rates continually rising in many countries (McKenzie et al., 2024). This condition is not only associated with metabolic disorders like type 2 diabetes but is also a major risk factor for various chronic diseases, including cardiovascular disease (CVD) (Rahmawati et al., 2024). Cardiovascular disease is one of the primary causes of morbidity and mortality among obese populations (Khafagy & Dash, 2021). Obese individuals tend to have higher systolic blood pressure (SBP) and diastolic blood pressure (DBP), as well as elevated resting heart rates (RHR) (Mathews et al., 2022; Palatini, 2021). These elevated parameters are directly linked to increased risks of hypertension, coronary heart disease, stroke, and other cardiovascular complications (Jiang et al., 2024; Choi et al., 2024).

Physiologically, obesity is often associated with endothelial dysfunction, high peripheral vascular resistance, and increased sympathetic nervous system activity (Kajikawa & Higashi, 2022; Clayton et al., 2023; Agabiti-Rosei et al., 2024). Excess adipose tissue, particularly visceral fat, triggers low-grade chronic inflammation and oxidative stress, worsening vascular function and impairing blood pressure regulation (Kawai et al., 2021). Sympathetic nervous system hyperactivity in obese individuals also contributes to elevated blood pressure through vasoconstriction, increasing vascular resistance (Tanaka, 2020; Parvanova et al., 2023). Additionally, an elevated RHR in obese populations indicates a higher cardiac workload, which, over time, may lead to cardiovascular dysfunction (Palatini et al., 2021). Therefore, there is an urgent need for effective interventions to reduce blood pressure and RHR and lower cardiovascular risk in obese populations (Hannan et al., 2022).

Physical exercise is a well-recognized non-pharmacological approach to improving cardiovascular health (Weaver et al., 2022). Endurance exercise is one of the most recommended forms of exercise due to its broad benefits on the cardiovascular system (Milani et al., 2024). Endurance activities, such as running, cycling, or swimming at moderate intensity, have been shown to reduce blood pressure and RHR, enhance cardiac function, and improve aerobic capacity (Kishor Keshari et al., 2023). The mechanisms behind these benefits include increased vascular elasticity, reduced vascular resistance, and enhanced stroke volume—all factors contributing to improved cardiovascular function (Totoń-Żurańska et al., 2024). Additionally, endurance exercise can reduce sympathetic nervous system activity, promoting vasodilation and lowering blood pressure (Königstein et al., 2023; Zhang et al., 2024; Baffour-Awuah et al., 2024; Cornelissen & Fagard, 2005). In obese populations, who often have impaired cardiovascular function, the benefits of endurance exercise may be particularly significant and relevant (Koskinas et al., 2024).

Although numerous studies have evaluated the effects of endurance training on the general population and athletes, there is still limited understanding of its impact on obese individuals, particularly in short-term training programs (Bauer et al., 2021; Said Ouamer et al., 2020; Jabbarzadeh Ganjeh, et al., 2024; Kajikawa & Higashi, 2024). Most existing studies have focused on long-term training, while the effects of shorter, more practical training programs that are easier to implement on a broad scale remain underexplored (Bora et al., 2024). If structured endurance training proves effective in a shorter timeframe, it could become a realistic and easily implemented intervention for obese individuals to incorporate into their daily routines. Therefore, it is important to investigate whether endurance training over several weeks can have a significant positive impact on cardiovascular parameters in obese individuals.

This study aims to evaluate the long-term effects of endurance training as a modulator in the prevention of cardiovascular disease risk in obese individuals. Specifically, this study aims to demonstrate the effects of eight weeks of endurance training, performed three times per week, on improving systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), and resting heart rate (RHR) in obese women.

Material and Methods

Experimental Study

This study utilized a true-experimental design with a pretest-posttest control group approach. Twenty-five obese women meeting the following inclusion criteria were randomly assigned to either a control group (CNT, n = 12) or an exercise group (EXC, n = 13): age 20-25 years, body mass index (BMI) ≥ 27-35 kg/m², body fat percentage ≥ 30 %, oxygen saturation 95-100 %, fasting blood glucose ≤ 100 mg/dL, and hemoglobin levels between 12-16 g/dL. Before participating, all participants were informed about the benefits, their right to withdraw at any time, and any potential risks associated with the intervention program. They voluntarily provided informed consent. All study protocols were approved by the Ethics Committee of Universitas Negeri Malang on June 20, 2024 (Approval No. 20.06.9/UN32.14.2.8/LT/2024).

Endurance Training Programs

The endurance training program was implemented and supervised by personal trainers from Atlas Sports Club Malang. Each participant was accompanied by a personal trainer to ensure the proper execution of the endurance training program. The endurance training was conducted using a treadmill (T5 Treadmill, Life Fitness, Co., Ltd, USA) set at a 0 % incline and a moderate intensity (60-70 % of HRmax). Each session lasted 40-60 minutes and was held three times a week (Tuesday, Thursday, and Saturday) over eight weeks. Exercise intensity was based on HRmax, calculated as 200 minus the participant's age, and monitored using a Polar H10 heart rate sensor. The training environment was maintained at a controlled room temperature and humidity (26 ± 1°C and 50-70 %, respectively).

Data Collection

Data collection involved measuring systolic and diastolic blood pressure using an automatic sphygmomanometer (OMRON HBP-9030; Omron Healthcare Co., Ltd, Osaka, Japan) (Pranoto et al., 2023), while resting heart rate was measured using a Polar H10 heart rate sensor (Polar Electric, Inc., Bethpage, NY, USA) (Rejeki et al., 2024). Assessments were conducted at baseline (pre) and after eight weeks (post) of endurance training. All assessments were performed in a temperature-controlled room (25˚C) between 7:00 and 9:00 AM.

Statistical Analysis

Normality testing was conducted to observe data distribution using the Shapiro–Wilk test. Parametric tests, including paired sample t-tests, were used to assess within-group differences (time: pre vs. post), while independent sample t-tests were employed to assess between-group differences (group: CNT vs. EXC) at a 95 % confidence level. The effect size was evaluated using Cohen's d. All data are presented as mean ± standard deviation (SD). Statistical analysis was conducted using SPSS for Windows, version 21 (SPSS Inc., Chicago, IL, USA).

Results

Participant's Characteristics in Research

All 25 obese women in both the CNT and EXC groups completed the baseline (pre) and eight-week (post) assessments with no dropouts observed (dropout rate = 0 %). Table 1 presents the analysis of participant characteristics, revealing no significant differences between the groups in age, anthropometric measurements, body fat percentage, resting heart rate, blood pressure, mean arterial pressure, oxygen saturation, fasting blood glucose, or hemoglobin levels (all $p \geq 0.05$).

Table 1. General characteristics of participants

Variable	CNT, n = 12	EXC, n = 13	p-value
Age (yrs)	22.25 ± 1.76	22.39 ± 1.26	0.827
Weight (kg)	73.68 ± 6.29	72.46 ± 8.99	0.698
Height (m)	1.57 ± 0.06	1.55 ± 0.05	0.386
BMI (kg/m^2)	30.07 ± 1.15	30.27 ± 2.52	0.806
PBF (%)	34.40 ± 2.53	33.49 ± 4.39	0.527
SpO_2 (%)	97.83 ± 1.12	98.08 ± 0.95	0.562
FBG (mg/dL)	91.00 ± 5.75	88.77 ± 6.74	0.384
Hb (g/dL)	14.83 ± 1.41	14.89 ± 1.36	0.927
Baseline SBP (mmHg)	127.72 ± 1.81	126.23 ± 2.98	0.144
Baseline DBP (mmHg)	83.75 ± 3.21	85.65 ± 3.03	0.142
Baseline MAP (mmHg)	98.41 ± 2.68	99.18 ± 2.18	0.438
Baseline RHR (bpm)	81.29 ± 2.21	80.96 ± 3.09	0.763

Effects of exercise on blood pressure, MAP, and RHR

Analysis results of blood pressure (BP), mean arterial pressure (MAP), and resting heart rate (RHR) are presented in Table 2 and Figures 1-4. A significant reduction in systolic blood pressure (SBP), diastolic blood pressure (DBP), MAP, and RHR was detected in the EXC group from pre- to post-training (all $p \leq 0.001$). In contrast, no significant changes were observed in the CNT group for SBP, DBP, MAP, and RHR (all $p \geq 0.05$).

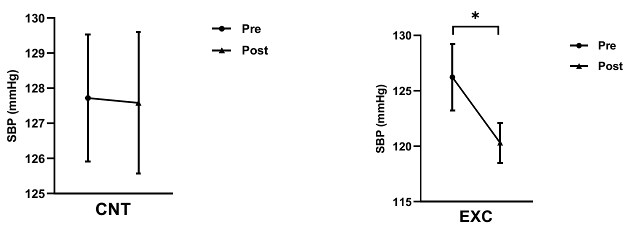

Fig. 1. SBP (mmHg) assessment at pre and post-endurance training. *Significant at pre in EXC group (p ≤ 0.001). Data are presented as mean ± SD

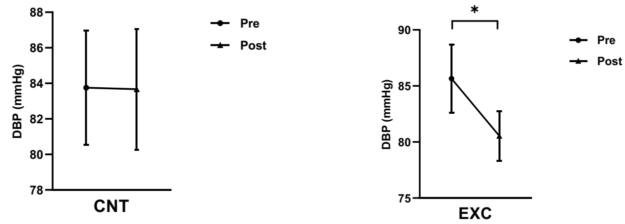

Fig. 2. DBP (mmHg) assessment at pre and post-endurance training. *Significant at pre in EXC group (p ≤ 0.001). Data are presented as mean ± SD

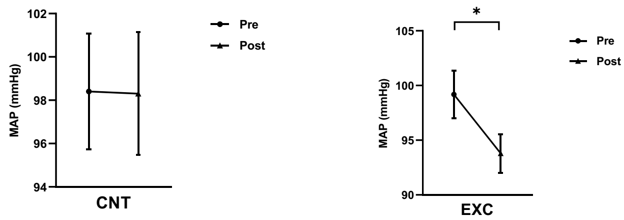

Fig. 3. MAP (mmHg) assessment at pre and post-endurance training. *Significant at pre in EXC group (p ≤ 0.001). Data are presented as mean ± SD

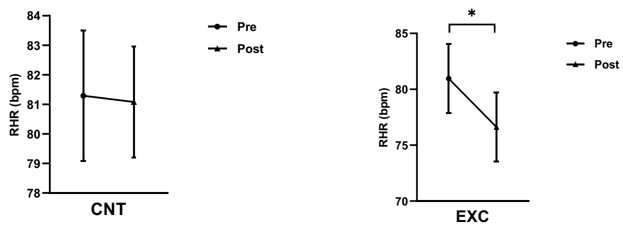

Fig. 4. RHR (bpm) assessment at pre and post-endurance training. *Significant at pre in EXC group (p ≤ 0.001). Data are presented as mean ± SD

Discussion

Eight weeks of endurance training, performed three times per week, resulted in significant reductions in systolic blood pressure (SBP), diastolic blood pressure (DBP),

Table 2. Blood pressure, MAP, and RHR assessment at baseline (pre) and week 8 (post)

Variable	Mean (SD)		95 % CI		p-value	ES d
	CTN, n=12	EXC, n=13	Lower	Upper		
Pre-SBP, mmHg	127.72 (1.81)	126.23 (2.98)	-0.56	3.53	0.144	0.602
Post-SBP, mmHg	127.58 (2.02)	120.31 (1.79)*	5.69	8.87	0.000	3.804
Δ-SBP, mmHg	-0.13 (1.20)	-5.92 (2.19)*	4.33	7.25	0.000	3.281
Pre-DBP, mmHg	83.75 (3.21)	85.65 (3.03)	-4.49	0.69	0.142	0.610
Post-DBP, mmHg	83.67 (3.39)	80.54 (2.22)*	0.71	5.55	0.014	1.091
Δ-DBP, mmHg	-0.08 (1.62)	-5.12 (1.62)*	3.69	6.38	0.000	3.102
Pre-MAP, mmHg	98.41 (2.68)	99.18 (2.18)	-2.82	1.26	0.438	0.317
Post-MAP, mmHg	98.31 (2.84)	93.79 (1.76)*	2.51	6.52	0.000	1.911
Δ-MAP, mmHg	-0.10 (1.46)	-5.39 (1.16)*	4.18	6.39	0.000	4.008
Pre-RHR, bpm	81.29 (2.21)	80.96 (3.09)	-1.89	2.55	0.760	0.123
Post-RHR, bpm	81.08 (1.88)	76.62 (3.09)*	2.35	6.59	0.000	1.743
Δ-RHR, bpm	-0.21 (1.57)	-4.35 (1.93)*	2.69	5.59	0.000	2.351

Data are presented as mean ± SD. *Significant at CNT group (p ≤ 0. 01). ES d: Effect size Cohen's d mean arterial pressure (MAP), and resting heart rate (RHR) among obese individuals. These reductions indicate improvements in cardiovascular function, which have direct implications for lowering cardiovascular disease (CVD) risk. Endurance training, which involves moderate- to high-intensity physical activity, enhances vascular elasticity and reduces peripheral vascular resistance (Zhang et al., 2024; Weston et al., 2022; Shishira et al., 2024). Repeated exercise sessions improve endothelial function through increased blood flow, which reduces blood pressure by decreasing vasoconstriction (Tanaka et al., 2024; Parvanova et al., 2023). For obese individuals, who generally exhibit higher peripheral resistance, these physiological adaptations are crucial for alleviating the typically elevated blood pressure burden compared to non-obese individuals (Gallo et al., 2024).

The significant reduction in RHR in the intervention group reflects an increase in cardiac efficiency (Moncion et al., 2024). Endurance training enhances stroke volume, which is the amount of blood pumped per heartbeat (Bennett & Solberg, 2023). This adaptation enables the heart to work more efficiently, requiring fewer beats to meet the body's needs at rest and during light physical activity (Scott et al., 2024). This reduction in RHR is a key indicator of increased aerobic capacity and overall heart health (Pozuelo-Carrascosa et al., 2021). Therefore, endurance training not only improves physical fitness but also reduces the heart's workload over the long term (Seo et al., 2023).

The findings of this study are consistent with previous research that has also reported the benefits of endurance training on cardiovascular parameters (Weaver et al., 2022). For example, a study by Jabbarzadeh Ganjeh et al. (2024) found that endurance training performed for 30 minutes weekly lowered SBP by 1.78 mmHg in patients with hypertension. Similarly, a meta-analysis by Reimers et al. (2018) reported that, after an average of 14 weeks of endurance training, participants showed a significant reduction in RHR compared to non-exercisers, with gender-based reductions ranging from 4.5 % to 9.0 % and 2.7 to 5.8 bpm, respectively. Although the duration of the current study's program was shorter (8 weeks), the results indicate that a moderate-frequency training regimen is sufficient to produce significant improvements in obese individuals. The fact that a relatively short and simple training intervention can lead to cardiovascular benefits in this population underscores the effectiveness of endurance training as a preventive intervention.

A major strength of this study is its simple, widely applicable intervention design. Conducting endurance training three times per week for eight weeks is an intervention that is feasible to implement in various clinical and community settings. This adds practical relevance to the study's findings, as a straightforward exercise program can be adopted independently by obese individuals with high cardiovascular risk. Additionally, the use of objective measurements such as SBP, DBP, MAP, and RHR, which are commonly used indicators of cardiovascular risk, makes these findings easily comparable to similar studies (Jiang et al., 2024; Choi et al., 2024).

Endurance exercise interventions can impact several physiological mechanisms associated with lowering blood pressure and RHR (Jabbarzadeh Ganjeh et al., 2024; Weaver et al., 2022). One primary mechanism is the reduction in sympathetic nervous system activity, which is typically hyperactive in obese individuals (Tanaka, 2020; Parvanova et al., 2023). Decreased sympathetic activity reduces catecholamine release, which is involved in vasoconstriction, thus promoting vasodilation and reducing vascular resistance (Motiejunaite et al., 2021). Increased stroke volume, as an adaptation of the heart to exercise, also contributes to a lower RHR (Wolsk et al., 2021). With increased cardiac efficiency, the resting heart rate can be lower, as the heart pumps more blood per beat (Bennett & Solberg, 2023).

The clinical implications of these findings are significant for the prevention of cardiovascular disease in obese individuals. The reductions in SBP, DBP, MAP, and RHR demonstrate that a simple yet consistent endurance training regimen can serve as an effective non-pharmacological intervention to lower the risks of hypertension, stroke, and coronary heart disease. Integrating endurance training programs into the management of obesity and cardiovascular risk provides a low-cost, safe, and accessible preventive measure with beneficial outcomes for high-risk individuals.

While the positive outcomes observed in this study are promising, certain limitations must be acknowledged. First, the intervention duration of only 8 weeks may not be sufficient to observe the long-term effects of endurance training, particularly regarding sustained reductions in CVD risk. Some vascular or metabolic adaptations require longer periods to stabilize and demonstrate their full effects (Green et al., 2017). Therefore, long-term studies are necessary to determine whether the cardiovascular benefits observed can be maintained or further enhanced over time. Second, this study focused on blood pressure and RHR parameters without including additional measures such as VO_2max, lipid profiles, or inflammatory markers. Including these parameters would provide a more comprehensive understanding of how endurance training affects metabolic and cardiovascular health.

Conclusion

The results of this study indicate that eight weeks of endurance training performed three times weekly consistently reduced SBP, DBP, MAP, and RHR in obese individuals. These findings highlight the potential of endurance training as an effective intervention for preventing cardiovascular disease risk in individuals with obesity. However, further research is needed to explore the long-term effects and to incorporate other relevant parameters to enrich the understanding of the physiological mechanisms underlying these changes.

Conflict of Interest

The authors declare that they have no conflicts interests.

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Довготривалі тренування з розвитку витривалості як модулятор профілактики ризику серцево-судинних захворювань у осіб з ожирінням

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 7 с., 2 табл., 4 рис., 42 джерела.

Мета дослідження. Метою цього дослідження було визначити довгостроковий вплив тренувань з розвитку витривалості як модулятора профілактики ризику серцево-судинних захворювань у осіб з ожирінням.

Матеріали та методи. У дослідженні застосовано метод «істинного експерименту», що включає претест-посттестовий дизайн контрольної групи. Двадцять п’ять жінок з ожирінням віком 20-30 років, які мали показник відсоткового вмісту жиру в організмі ≥30 %, було розподілено на контрольну групу (КГ) та групу, що виконувала фізичні вправи (ФВГ). ФВГ проходила восьмитижневу (три заняття на тиждень) програму тренувань з розвитку витривалості (із використанням бігової доріжки) з тривалістю заняття 40-60 хвилин. Вимірювання кров’яного тиску (КТ), середнього артеріального тиску (САТ) та частоти серцевих скорочень (ЧСС) у стані спокою проводили за допомогою цифрового тензіометра OMRON HBP-9030 та датчика частоти серцевих скорочень Polar H10 на початку (передтренувальний етап) та через вісім тижнів (посттренувальний етап) виконання фізичних вправ з розвитку витривалості.

Результати. Встановлено значне зниження показників систолічного артеріального тиску (САТ), діастолічного артеріального тиску (ДАТ), середнього артеріального тиску і ЧСС у стані спокою між етапами перед початком і після завершення програми тренування на витривалість (всі показники на рівні $p \leq 0{,}001$). Крім того, між групами спостерігалося суттєве зниження систолічного артеріального тиску, діастолічного артеріального тиску, середнього артеріального тиску і ЧСС у стані спокою (всі показники на рівні $p \leq 0{,}05$).

Висновки. Отримані дані свідчать про ефективність застосування програми щодо виконання восьмитижневих тренувань з розвитку витривалості, що сприяє послідовному зниженню показників систолічного артеріального тиску, діастолічного артеріального тиску, середнього артеріального тиску і ЧСС у стані спокою у жінок з ожирінням.

Ключові слова: кров’яний тиск, серцево-судинні захворювання, ожиріння, фізичні вправи.

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