Теорія та методика фізичного виховання
Physical Education Theory and Methodology
Teorìâ ta Metodika Fìzičnogo Vihovannâ

ISSN 1993-7989 (print)
ISSN 1993-7997 (online)
ISSN-L 1993-7989

ORIGINAL SCIENTIFIC ARTICLE

PHYSICAL EXERCISE AS A PHYSIOLOGICAL MODULATOR OF IMPROVING CARDIOVASCULAR HEALTH IN OBESE WOMEN

Sugiharto[1ABD], Desiana Merawati[1ABD], Adi Pranoto[2BCD], Mashuri Eko Winarno[1BD], Asim[1BD], Hendra Susanto[1ABD] and Ahmad Taufiq[1BCD]

[1]Universitas Negeri Malang
[2]Universitas Airlangga

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Corresponding Author: Sugiharto, E-mail: sugiharto@um.ac.id
Accepted for Publication: May 19, 2023
Published: June 30, 2023

DOI: 10.17309/tmfv.2023.3.08

Abstract

The study purpose was to analyze the effective form of physical exercise in improving cardiovascular health in obese individuals.

Materials and methods. Twenty-four (24) obese adolescents, aged 20–24 years, who met the criteria were selected as participants. The participants were divided into 3 groups, namely the control, the strength training, and the endurance training, with 8 participants in each group. Strength training was done with Machine Fitness, while endurance training used a Treadmill. Exercise was done with moderate intensity, for 35 minutes, the frequency of exercise was 3x/week, for 1 month. Heart rate and blood pressure, as parameters of heart health, were measured before and after treatment. Data analysis used the One-way ANOVA test with a significance level of 5%.

Results. The results showed that there was a significant difference in cardiovascular health between endurance and strength training ($p \leq 0.05$).

Conclusions. Based on the study results, it was shown that endurance training is a potential physiological modulator to improve cardiovascular health in obese women.

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

Introduction

Obesity is a very complex health problem (Chen et al., 2021), and is an independent factor, increasing the risk of heart disease, type 2 diabetes mellitus, and other diseases (Jamka et al., 2021). It was found that an increase in obesity was directly proportional to an increase in heart disease (Amaral, 2014), and in overweight individuals have twice the probability of developing heart disease, in obese individuals the probability rate can reach 10 times that of individuals with normal weight (Pinckard et al., 2019). However, in modern society heart disease is still considered the most common health condition (Machado et al., 2021), with its main contribution to high blood pressure (Schroeder et al., 2019), which has the highest prevalence rate (Shim & Kim, 2017). Data shows that high blood pressure reaches 29% and is predicted to continue to increase, as well as being the main risk of death (Schroeder et al., 2019). It is estimated that 25% of deaths each year are due to heart disease (Jamka et al., 2021), and the prevalence rate increases to 31% deaths every year (Brandão et al., 2022). Therefore, heart disease can be a major risk factor for increased mortality and morbidity (Pinckard et al., 2019).

Obesity is a significant contributor to an increase in heart disease, especially high blood pressure (Tayagi et al., 2020), myocardial infarction, (Almutawa et al., 2020) and coronary artery disease, (Machado et al., 2021), is also a major risk factor for death (Schroeder et al., 2019). Pharmacological approach (Zimmer et al., 2019) and an eating behavior change approach using diet in combination with medication (Shim & Kim, 2017). It has been used to treat heart disease and cardiovascular health. However, other experts stated that the approach with drugs (pharmacology) in the long term is still considered less than ideal (Almutawa et al., 2020). Meanwhile, other experts stated that the approach with physical exercise was more appropriate and physiological to improve heart health in the long term (Ramos et al., 2019) and physical exercise is also considered an effective codulation not only for heart health, but also for improving cardiac performance (Durrani & Fatima, 2015). Physical exercise, is a modulation associated with the level of energy expenditure, decreased fat mass and increased skeletal muscle mass as well as heart muscle (Saeidi et al., 2022; Rejeki et al., 2021).

Physical exercise is very beneficial, not only for heart health but also for general health, which is believed to be an effective non-drug method of lowering and replacing drug doses (Shim & Kim, 2017), thereby so as to reduce and prevent non-communicable diseases including improving heart health (Thirupathi et al., 2021). Previous research has shown that regular physical exercise increases high-density lipoprotein (HDL), controls insulin resistance, reduces risk factors for heart disease and reduces the incidence of death (Oh et al., 2016). Physical exercise also improves weight management, preventing excessive increases in blood pressure over time (Durrani & Fatima, 2015). Adaptation response to physical exercise depends on: frequency, intensity, time, and form of exercise (Saeidi et al., 2022). Previous research suggests that forms of endurance training and strength training can be an alternative in reducing obesity and improving heart health, although resistance training is still considered more effective in improving heart health than strength training (Schroeder et al., 2019). Strength training is thought to have little effect on improving heart health (Shim & Kim, 2017). In contrast, endurance training for reducing the risk of heart disease and increasing parasympathetic activity (Grässler et al., 2021). However, the analysis of the effectiveness of power training and strength training on cardiac performance has not been widely reported. The form of endurance training is still unclear in terms of intensity and duration, compared to strength training which will also increase muscle mass and cause muscle hypertrophy (Machado et al., 2021). Therefore, this study aims to analyze the adaptive response of strength training and endurance training as a physiological modulator in improving cardiovascular health in obese adolescent womens.

Materials and Methods

Study participants

This study is an experimental study that aims to analyze differences in strength and endurance training as a physiological modulator of improving cardiovascular health in obese adolescent girls. This study involved 24 obese adolescents, female gender, age 20-24 years, body mass index (BMI) 27-35 kg/m^2, normal oxygen saturation (SpO_2). Participants were divided into 3 groups: control, strength training, and endurance training. The division of groups was done randomly, each group of 8 participants. Prior to the study all participants were given an explanation of the research problem and procedure, both written and verbal. All participants, both verbally and in writing, expressed their willingness. Likewise, participants also received an explanation of the physical exercise procedures during treatment.

This study was approved by the ethics committee of the institution and conducted in accordance with the guidelines of the Helsinki Declaration. Informed consent was obtained from all participants.

Study design

Warming up and cooling down, with static and dynamic stretching and running on a treadmill. Light intensity is used for heating and cooling. Each group started at 06.00-10.00 A.M., at the same time on different days. Strength training is done by lifting moderate intensity weights, for 35 minutes. Exercises are performed at intervals, 12 repetitions, 6 sets, with active rest between sets for 30 seconds. While endurance training was done by means of participants running on a treadmill for 35 minutes continuously, with moderate-intensity (60-70% HRmax). Exercise is done 3x/week for 4 weeks. Heart rate monitored using Polar H10. Physical exercise intervention will be temporarily stopped if physical signs are found, shortness of breath, sharply increased heart rate, dizziness and pale face.

Measurement of heart health using parameters of systolic and diastolic blood pressure and resting heart rate. Measurement of heart health was carried out before exercise and 4 weeks after the last exercise, while measurements of height and weight were carried out before exercise. Blood pressure was measured using an OMRON digital blood pressure meter.

Statistical analysis

Data analysis used the one-way ANOVA, which was followed by the Tukey's Honestly Significant Deference (HSD) post-hoc test, with a significant level of 5%.

Results

Characteristics of research participants, based on the results of descriptive statistical analysis in each group are presented in Table 1 below.

Based on the analysis of participant characteristics: resting heart rate, normal systolic and diastolic blood pressure (Table 1). The characteristics of the participants did not show any significant difference (p ≥0.05). Therefore, if there is a difference in heart health, which in this study used blood pressure and heart rate parameters after exercise, it can be believed to be the effect of the intervention given for 4 weeks. The results of the analysis of physical exercise as a modulator of cardiovascular health, in reducing systolic blood pressure in each group (Figure 1).

Physical exercise as a modulator of cardiovascular health in reducing systolic blood pressure between before exercise

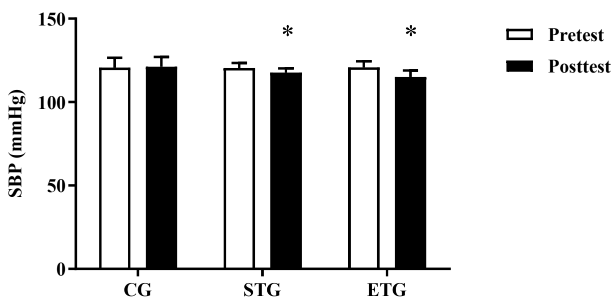

Fig. 1. Analysis of systolic blood pressure between pretest and posttest in the three groups

Description: SBP: Systolic blood pressure.

(*) Significant vs. Pretest (p ≤ 0.001)

Table 1. Analysis of the characteristics of research participants

Parameter	CG	STG	ETG	p-value
Age, years	21.88±1.46	21.63±1.41	22.25±1.28	0.667
BH, m	1.57±0.07	1.58±0.05	1.55±0.06	0.786
BW, kg	74.37±12.32	73.63±6.78	71.41±6.07	0.588
BMI, kg/m^2	29.67±4.25	29.46±2.98	29.78±3.27	0.983
SBP, mmHg	120.13±6.29	120.25±4.33	120.63±2.67	0.976
DBP, mmHg	82.25±6.27	82.50±5.73	84.38±7.89	0.788
RHR, bpm	80.25±3.49	81.13±4.02	80.63±8.98	0.958
SpO_2, %	97.50±1.19	97.63±1.18	98.13±1.13	0.538

Description: CG: Control group; STG: Strength training group; ETG: Endurance training group. p-value obtained by using One-way ANOVA test. Data are shown with mean ± SD. BH: Body height; BW: Body weight; BMI: Body mass index; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; RHR: Resting heart rate; SpO_2: Oxygen saturation.

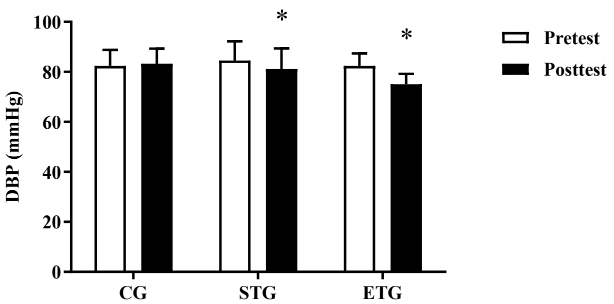

Fig. 2. Analysis of diastolic blood pressure between pretest and posttest in the three groups
Description: DBP: Diastolic blood pressure.
(*) Significant vs. Pretest (p ≤ 0.001)

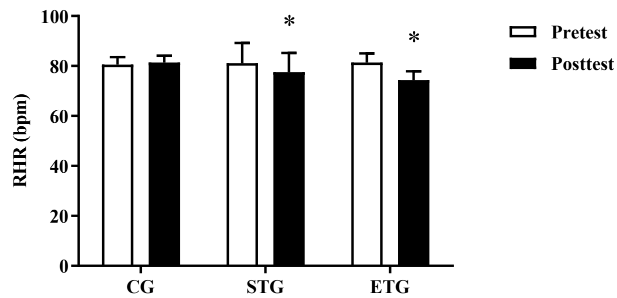

Fig. 3. Analysis of resting heart rate between pretest vs. posttest in the three groups
Description: RHR: Resting heart rate.
(*) Significant vs. Pretest (p ≤ 0.001)

Table 2. Analysis of cardiovascular health pretest and posttest

Parameter	CG	STG	ETG	p-value
Systolic Blood Pressure (mmHg)				
Pretest	120.63±5.88	120.38±3.11	120.75±3.69	0.985
Posttest	121.13±5.94	117.63±2.56	115.00±3.96*	0.035
Delta	0.50±0.33	-2.75±1.04**	-5.75±1.75**#	0.000
Diastolic Blood Pressure (mmHg)				
Pretest	82.38±6.44	84.50±7.71	82.37±5.01	0.754
Posttest	83.25±6.04	81.13±8.24	75.00±4.17*	0.045
Delta	0.88±1.25	-3.37±1.19**	-7.38±1.92**#	0.000
Resting Heart Rate (bpm)				
Pretest	80.50±3.02	81.13±8.11	81.38±3.70	0.947
Posttest	81.38±2.77	77.50±7.75	74.38±3.50	0.042
Delta	0.88±0.61	-3.63±1.41**	-7.00±1.31**#	0.000

Description: *Significant vs. CG (p ≤ 0.05); **Significant vs. CG (p ≤ 0.001); #Significant vs. STG (p ≤ 0.001).

and after exercise in the control group did not show any significant difference (p ≥ 0.05). However, in the treatment group there was a significant difference in systolic blood pressure in both strength training and endurance training (p ≤ 0.001). Systolic blood pressure was lower after exercise than before exercise in both the strength training and endurance training groups (Figure 1 and Table 2). Further analysis of changes in diastolic blood pressure before and after treatment in each group in Figure 2.

The data analysis of diastolic blood pressure in the control group between before and after treatment there was no significant difference (p ≥ 0.05). There was a significant difference in diastolic blood pressure between before and after exercise in the strength training and endurance training groups ($p \leq 0.001$). The study also showed that diastolic blood pressure after treatment was lower than before exercise (Figure 2 and Table 2). Analysis of physical exercise as a modulator of decreasing resting heart rate before and after treatment in each group (Figure 3).

Analysis of resting heart rate before treatment and after treatment in the control group, did not show a significant difference ($p \geq 0.05$) (Figure 3 Table 2), but there was a significant difference in resting heart rate pretest and posttest in the strength training and exercise groups. endurance ($p \leq 0.001$). Our data show that resting heart rate is lower, after strength training and endurance training, than before treatment (Figure 3 and Table 2). One-way ANOVA analysis of the decrease in blood pressure (systolic and diastolic) and resting heart rate before treatment showed no significant difference ($p \geq 0.05$) (Table 2).

Discussion

The results of this study prove that physical exercise is done properly and regularly, a very important factor for maintaining heart health and fighting various diseases (Souissi et al., 2020). Physical exercise, as the basis for lifestyle change interventions in preventing as heart disease (Rejeki et al., 2021; Andarianto et al., 2022; Rejeki et al., 2021). The findings of this study prove that moderate-intensity exercise, frequency 3x/week for 4 weeks, improves cardiovascular health in obese adolescent female participants (Table 2). The improvement in heart health can be seen from the decrease in systolic blood pressure, diastolic and resting heart rate after strength training and endurance training (Figure 1-3, Table 2). Several previous studies, which are similar to this study, also found that individuals who limit their passive and active lifestyle to physical exercise have normal blood pressure, stable body weight (Durrani & Fatima, 2015), higher cardiac output, blood pressure, lower resting heart rate, higher insulin sensitivity, better plasma lipoprotein profile than someone who is physically inactive (Nystoriak & Bhatnagar, 2018). Research identical to this study also found a decrease in blood pressure and resting heart rate after doing an endurance training program and strength training 3x/week, (Jamka et al., 2021). Research with walking intervention and crossfit exercise on participants in the age group 14 – 38 years, significantly lowers blood pressure (Almutawa et al., 2020), also found stronger heart muscle, decreased sympathetic nerve activity and decreased resting heart rate ≤ 60 bpm in marathon runners (Oh et al., 2016). Durrani's research involving 701 participants, children aged 12-16 years, found a relationship between physical activity and blood pressure (Durrani & Fatima, 2015). In another study, someone who did regular physical exercise found a decrease of 20 mmHg in systolic blood pressure and 11 mmHg in diastole (Kui et al., 2022). In addition, physical exercise was found to cardiac morphological changes that will cause aortic diameter widening accompanied by left ventricular fibrosis, improve oxidative profile and metabolic health (Dupuy et al., 2022).

The improvement in cardiovascular health is the effect of exercise adaptation in increasing the promoting increased vasodilation through relaxation of vascular smooth muscle cells. Given this effect, it is important to decrease the activity of Endothelial Nitric Oxide Synthase (eNOS), which contributes to blood pressure (Ramos et al., 2019). Resting heart rate and blood pressure were lower than the control group and before exercise, this shows that exercise is able to modulate changes in the heart system, both in form and function, thereby improving cardiovascular health. Exercise is believed to be a modulation of changes in heart size, as a result of increasing left and right ventricular cavities and increasing the thickness of the heart muscle wall and cardiac septum. Endurance training is believed to be beneficial exercise to improve heart function, such as decreasing heart rate. The heart rate is estimated to decrease by 10-15 bpm, that the individual is able to work hard efficiently (Pinckard et al., 2019).

Our study findings also show that heart rate and blood pressure are lower in endurance training than in strength training. Endurance training in general increases the oxidative ability to meet oxidative demands, the heart will contract and relax, cardiomyocytes and increase the strength of heart contraction, which is more optimal than strength training. The rate of contraction and relaxation requires increased adaptation of the cardiomyocyte contractile system, which is associated with an increase and the rate of intracellular $Ca2+$ release. Coordination between $Ca2+$ mediated $Ca2+$ type L channels and activation of the ryanodine receptor (RyR). This causes an increase in $Ca2+$ ion sensitivity, resulting in greater force and speed of contraction after exercise (Nystoriak & Bhatnagar, 2018). A decrease in blood pressure and heart rate is a complex event, many factors influence it, an increase in peripheral vascular resistance and autonomic nervous activity is the most important mechanism (Oh et al., 2016).

Improved heart health is strongly suspected to be the effect of endurance exercise, as a modulator of changes in fat mass (Shim & Kim, 2017). Therefore, endurance training is described as the optimal form for reducing the risk of heart disease and increasing parasympathetic activity (Grässler et al., 2021). Previous studies have also reported that endurance training induces greater improvements in cardiorespiratory fitness and cardio-metabolic variables (Schroeder et al., 2019), decreased acute stress reactivity and decreased heart rate and heart rate variability compared to the control group (Arvidson et al., 2020). Strength training also has a modulating effect on cardiac performance, although not as high as resistance training. Strength training, affects the increase in the strength of heart muscle contraction, heart muscle endurance, and reduces damage to the inner walls of blood vessels, to improve blood vessel function (Shim & Kim, 2017). Strength of heart muscle contraction, is the impact of strength training that causes cardiac muscle hypertrophy, skeletal muscle hypertrophy. Hypertrophy causes an increase in stronger contractions and a more complete emptying process in systole, with greater stroke volume and cardiac output (Schroeder et al., 2019). Therefore, both forms of exercise in this study are beneficial for the obese group, in addition to improving cardiovascular health, this exercise is also believed to initiate an increase in muscle mass and decrease fat mass in obesity (Sugiharto et al., 2022; Sugiharto et al., 2021; Sugiharto et al., 2022).

The findings of this study provide a starting point for understanding exercise as a modulator of improved cardiovascular health, and provide a solid foundation for understanding that well-organized exercise causes response and adaptation. Response and adaptation to exercise not only change shape, but also function in all body systems, not only the heart. Although exercise modulation for 4 weeks, in improving heart health may not be optimal. However, training for 4 weeks is the beginning of the adaptation process to the exercise program, as described in the general adaptation of the body. But this research also has limitations, among others the study participants only used one group of obese adolescent girls, on heart health, this study has not measured the parameters of changes in body fat, muscle mass and changes in the endothelium associated with heart health. In addition, they have not been able to fully control the physical activities carried out, outside the exercise program that has been set for 4 weeks. Perhaps the results of this study cannot be generalized to all age groups and genders. However, the findings of this study still have significance in developing the science of exercise physiology, by providing substantial data and information, and opening up opportunities for further research.

Conclusion

Overall, it was concluded that endurance and strength exercise moderate intensity, for four weeks improved cardiovascular health, by decreasing blood pressure and resting heart rate. However, endurance training lowers resting blood pressure and heart rate more than strength training, therefore endurance training can be recommended as a modulator to improve cardiovascular health in obesity.

Acknowledgments

This study was supported by the 2022 PNBP research grant, State University of Malang, Indonesia, with Grant Number: 19.5.577/UN32.20.1/LT/2022. We also thank all participants, research assistants, and laboratory assistants who have been involved in this study.

References

Chen, T., Lin, J., Lin, Y., Xu, L., Lu, D., Li, F., Hou, L., & Yu, C.C.W. (2021). Effects of aerobic exercise and resistance exercise on physical indexes and cardiovascular risk factors in obese and overweight school-age children: A systematic review and meta-analysis. *PLoS ONE,* 16, e0257150. https://doi.org/10.1371/journal.pone.0257150

Jamka, M., Mądry, E., Krzyżanowska-Jankowska, P., Skrypnik, D., Szulińska, M., Mądry, R., Lisowska, A., Batyrova, G., Duś-Żuchowska, M., Gotz-Więckowska, A., Bogdański, P., & Walkowiak, J. (2021). The effect of endurance and endurance-strength training on body composition and cardiometabolic markers in abdominally obese women: A randomised trial. *Scientific Reports, 11*(1), 12339. https://doi.org/10.1038/s41598-021-90526-7

Amaral, J. (2014). Cardiac autonomic regulation during exposure to auditory stimulation with classical baroque or heavy metal music of different intensities. Turk Kardiyoloji Dernegi Arsivi-Archives of the Turkish Society of Cardiology, 42(2), 139-146. https://doi.org/10.5543/tkda.2014.39000

Pinckard, K., Baskin, K. K., & Stanford, K. I. (2019). Effects of Exercise to Improve Cardiovascular Health. *Frontiers in Cardiovascular Medicine,* 6, 69. https://doi.org/10.3389/fcvm.2019.00069

Machado, M.V., Barbosa, T. de P.C., Chrispino, T.C., Junqueira das Neves, F., Rodrigues, G.D., Soares, P.P. da S., & Nóbrega, A.C.L. da (2021). Cardiovascular and Autonomic Responses after a Single Bout of Resistance Exercise in Men with Untreated Stage 2 Hypertension. *International Journal of Hypertension,* 2021, 1-10. https://doi.org/10.1155/2021/6687948

Schroeder, E. C., Franke, W. D., Sharp, R. L., & Lee, D. (2019). Comparative effectiveness of aerobic, resistance, and combined training on cardiovascular disease risk factors: A randomized controlled trial. *PLOS ONE, 14*(1), e0210292. https://doi.org/10.1371/journal.pone.0210292

Shim, K.-S., & Kim, J.-W. (2017). The effect of resistance exercise on fitness, blood pressure, and blood lipid of hypertensive middle-aged men. *Journal of Exercise Rehabilitation, 13*(1), 95-100. https://doi.org/10.12965/jer.1734894.447

Brandão, M. P., Sa-Couto, P., Gomes, G., Beça, P., & Reis, J. (2022). Factors Associated with Cardiovascular Disease Risk among Employees at a Portuguese Higher Education Institution. *International Journal of Environmental Research and Public Health, 19*(2), 848. https://doi.org/10.3390/ijerph19020848

Tayagi, N. K., Solanky, A., Jamali, S. N., Azharuddin, M., Ali, K., & Ahmad, I. (2020). Aerobic Training, in Combination with Listening Music, Changes Post-Exercise Cardiac Autonomic Function in Collegiate Overweight and Obese Individuals. *Asian Journal of Sports Medicine, 11*(1). https://doi.org/10.5812/asjsm.97122

Almutawa, A. M., Al-Shelash, A. A., Al-Gazlan, B. M., Al-Sallali, R. M., Al-Marzougi, R. A., & Al-Sowayan, N. S. (2020). The Effects of Different Quality of Exercise on Blood Pressure and Heart Rate in Healthy Female. *Health, 12*(04), 425-435. https://doi.org/10.4236/health.2020.124034

Zimmer, P., Bansi, J., Rademacher, A., Schlagheck, M., Walzik, D., Proschinger, S., Bloch, W., & Joisten, N. (2019). Exercise-neuroimmunology – from bench to bedside. *Deutsche Zeitschrift Für Sportmedizin, 70*(10), 227-234. https://doi.org/10.5960/dzsm.2019.392

Ramos, A. M., Senna, G. W., Scudese, E., Dantas, E. H. M., Silva-Grigoletto, M. E. D., Fuqua, J. D., & Pardono, E. (2019). Cardiovascular and strength adaptations in concurrent training in hypertensive women. *Revista Brasileira de Medicina Do Esporte, 25*(5), 367-371. https://doi.org/10.1590/1517-869220192505200493

Durrani, A. M., & Fatima, W. (2015). Effect of Physical Activity on Blood Pressure Distribution among School Children. *Advances in Public Health,* 2015, 1-4. https://doi.org/10.1155/2015/379314

Saeidi, A., Shishvan, S. R., Soltani, M., Tarazi, F., Doyle-Baker, P. K., Shahrbanian, S., Mollabashi, S. S., Khosravi, N., Laher, I., Moriarty, T. A., Johnson, K. E., VanDusseldorp, T. A., & Zouhal, H. (2022). Differential Effects of Exercise Programs on Neuregulin 4, Body Composition and Cardiometabolic Risk Factors in Men With Obesity. *Frontiers in Physiology,* 12, 797574. https://doi.org/10.3389/fphys.2021.797574

Rejeki, P.S., Pranoto, A., Prasetya, R.E., & Sugiharto. (2021). Irisin serum increasing pattern is higher at moderate-intensity continuous exercise than at moderate-intensity interval exercise in obese females. *Comparative Exercise Physiology, 17*(5), 475-484. https://doi.org/10.3920/CEP200050

Thirupathi, A., Wang, M., Lin, J.K., Fekete, G., István, B., Baker, J.S., Gu, Y. (2021). Effect of Different Exercise Modalities on Oxidative Stress: A Systematic Review. *BioMed Research International,* 2021, 1-10. https://doi.org/10.1155/2021/1947928

Oh, D.-J., Hong, H.-O., & Lee, B.-A. (2016). The effects of strenuous exercises on resting heart rate, blood pressure, and maximal oxygen uptake. *Journal of Exercise Rehabilitation, 12*(1), 42-46. https://doi.org/10.12965/jer.150258

Grässler, B., Thielmann, B., Böckelmann, I., & Hökelmann, A. (2021). Effects of Different Training Interventions on Heart Rate Variability and Cardiovascular Health and Risk Factors in Young and Middle-Aged Adults: A Systematic Review. *Frontiers in Physiology,* 12, 657274. https://doi.org/10.3389/fphys.2021.657274

Souissi, W., Bouzid, M. A., Farjallah, M. A., Ben Mahmoud, L., Boudaya, M., Engel, F. A., & Sahnoun, Z. (2020). Effect of Different Running Exercise Modalities on Post-Exercise Oxidative Stress Markers in Trained Athletes. *International Journal of Environmental Research and Public Health, 17*(10), 3729. https://doi.org/10.3390/ijerph17103729

Andarianto, A., Rejeki, P.S., Sakina, Pranoto, A., Seputra, T.W.A., Sugiharto, & Miftahussurur, M. (2022). Inflammatory markers in response to interval and continuous exercise in obese women. *Comparative Exercise Physiology, 18*(2), 135-142. https://doi.org/10.3920/CEP210038

Rejeki, P.S., Utami, D.M., Izzatunnisa, N., Pranoto, A., Sukarno, D.A., & Fasitasari, M. (2021). High-fat diet decreases serum TNF-alpha and breast tumor area on benzopyrene induced mice (Mus musculus). *Chiang Mai University Journal of Natural Sciences, 20*(4). https://doi.org/10.12982/CMUJNS.2021.089

Nystoriak, M. A., & Bhatnagar, A. (2018). Cardiovascular Effects and Benefits of Exercise. *Frontiers in Cardiovascular Medicine,* 5, 135. https://doi.org/10.3389/fcvm.2018.00135

Kui, P., Polyák, A., Morvay, N., Tiszlavicz, L., Nagy, N., Ördög, B., Takács, H., Leprán, I., Farkas, A., Papp, J. Gy., Jost, N., Varró, A., Baczkó, I., & Farkas, A. S. (2022). Long-Term Endurance Exercise Training Alters Repolarization in a New Rabbit Athlete's Heart Model. *Frontiers in Physiology,* 12, 741317. https://doi.org/10.3389/fphys.2021.741317

Dupuy, A., Birat, A., Maurelli, O., Garnier, Y. M., Blazevich, A. J., Rance, M., & Ratel, S. (2022). Post-exercise heart rate recovery and parasympathetic reactivation are comparable between prepubertal boys and well-trained adult male endurance athletes. *European Journal of Applied Physiology, 122*(2), 345-355. https://doi.org/10.1007/s00421-021-04823-0

Arvidson, E., Dahlman, A. S., Börjesson, M., Gullstrand, L., & Jonsdottir, I. H. (2020). The effects of exercise training on hypothalamic-pituitary-adrenal axis reactivity and autonomic response to acute stress – A randomized controlled study. *Trials, 21*(1), 888. https://doi.org/10.1186/s13063-020-04803-3

Sugiharto., Merawati, D., Susanto, H., Pranoto, A., & Taufiq, A. (2022). The exercise-instrumental music program and irisin levels in younger non-professional athletes. *Comparative Exercise Physiology, 18*(1), 65-73. https://doi.org/10.3920/CEP210015

Sugiharto, Merawati, D., Pranoto, A., Rejeki, P.S., Lupita, M.N., Adji, B.S., Susanto, H., & Taufiq, A. (2021). Acute Interval and Continuous Moderate-Intensity Exercise Enhanced Circadian Thermogenic Activity through Browning-related Genes in Obese Adolescent Female. *Malaysian Journal of Fundamental and Applied Sciences, 17*(5), 566-581. https://doi.org/10.11113/mjfas.v17n5.2271

Sugiharto, Merawati, D., Pranoto, A., & Susanto, H. (2023). Physiological response of endurance exercise as a growth hormone mediator in adolescent women's. *Journal of Basic and Clinical Physiology and Pharmacology, 34*(1), 61-67. https://doi.org/10.1515/jbcpp-2022-0060

ФІЗИЧНІ ВПРАВИ ЯК ФІЗІОЛОГІЧНИЙ МОДУЛЯТОР ПОКРАЩЕННЯ ЗДОРОВ'Я СЕРЦЕВО-СУДИННОЇ СИСТЕМИ В ЖІНОК З ОЖИРІННЯМ

Сугіхарто[1ABD], Десіана Мераваті[1ABD], Аді Праното[2BCD], Машурі Еко Вінарно[1BD], Асім[1BD], Хендра Сусанто[1ABD], Ахмад Тауфік[1BCD]

[1]Малангський державний університет
[2]Університет Айрланга

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

Реферат. Стаття: 5 с., 2 табл., 2 рис., 28 джерел.

Метою дослідження було проаналізувати ефективну форму фізичних вправ для покращення здоров'я серцево-судинної системи в осіб з ожирінням.

Матеріали та методи. Учасницями були відібрані двадцять чотири (24) молоді жінки з ожирінням віком 20-24 роки, які відповідали критеріям. Учасниць розподілили на 3 групи: контрольну, групу силових тренувань і групу тренувань на витривалість, по 8 учасниць у кожній групі. Силові тренування проводилися з використанням силових тренажерів, а для тренувань на витривалість використовували бігову доріжку. Вправи виконували за середньої інтенсивності, по 35 хвилин, частота – 3 рази на тиждень, протягом 1 місяця. Частоту серцевих скорочень та артеріальний тиск, як параметри здоров'я серця, вимірювали до та після процедур. Для аналізу даних використовували однофакторний дисперсійний аналіз за рівня значущості 5%.

Результати. Результати показали наявність статистично значущої різниці у здоров'ї серцево-судинної системи між тренуваннями на витривалість і силовими тренуваннями ($p \le 0{,}05$).

Висновки. На підставі результатів дослідження було показано, що тренування на витривалість є потенційним фізіологічним модулятором для покращення здоров'я серцево-судинної системи в жінок з ожирінням.

Ключові слова: здоров'я серцево-судинної системи, фізичні вправи, ожиріння, кров'яний тиск.

Information about the authors:

Sugiharto: sugiharto@um.ac.id; https://orcid.org/0000-0002-2561-9921; Department of Sport Science, Faculty of Sport Science, Universitas Negeri Malang, Jl. Semarang No.5, Sumbersari, Kec. Lowokwaru, Kota Malang, Jawa Timur 65145, Indonesia.

Merawati, Desiana: desiana.merawati.fik@um.ac.id; https://orcid.org/0000-0002-4586-457X; Department of Sport Science, Faculty of Sport Science, Universitas Negeri Malang, Jl. Semarang No.5, Sumbersari, Kec. Lowokwaru, Kota Malang, Jawa Timur 65145, Indonesia.

Pranoto, Adi: adipranoto83@gmail.com; https://orcid.org/0000-0003-4080-9245; Doctoral Program of Medical Science, Faculty of Medicine, Universitas Airlangga, Jl. Mayjen Prof. Dr. Moestopo No.47, Pacar Kembang, Kec. Tambaksari, Kota SBY, Jawa Timur 60132, Indonesia.

Winarno, Mashuri Eko: m.e.winarno.fik@um.ac.id; https://orcid.org/0000-0002-2064-5418; Department of Physical Education, Faculty of Sport Science, Universitas Negeri Malang, Jl. Semarang No.5, Sumbersari, Kec. Lowokwaru, Kota Malang, Jawa Timur 65145, Indonesia.

Asim: asim.fik@um.ac.id; https://orcid.org/0009-0006-0738-3990; Department of Physical Education, Faculty of Sport Science, Universitas Negeri Malang, Jl. Semarang No.5, Sumbersari, Kec. Lowokwaru, Kota Malang, Jawa Timur 65145, Indonesia.

Susanto, Hendra: hendrabio@um.ac.id; https://orcid.org/0000-0002-3935-4848; Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Negeri Malang, Jl. Semarang No.5, Sumbersari, Kec. Lowokwaru, Kota Malang, Jawa Timur 65145, Indonesia.

Taufiq, Ahmad: ahmad.taufiq.fmipa@um.ac.id; https://orcid.org/0000-0002-0155-6495; Department of Physics, Faculty of Mathematics and Natural Sciences, Universitas Negeri Malang, Jl. Semarang No.5, Sumbersari, Kec. Lowokwaru, Kota Malang, Jawa Timur 65145, Indonesia.

Cite this article as: Sugiharto, Merawati, D., Pranoto, A., Winarno, M. E., Asim, Susanto, H., & Taufiq, A. (2023). Physical Exercise as a Physiological Modulator of Improving Cardiovascular Health in Obese Women. *Physical Education Theory and Methodology, 23*(3), 366-372. https://doi.org/10.17309/tmfv.2023.3.08

Received: 10.11.2022. Accepted: 19.05.2023. Published: 30.06.2023