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

Engaging in Short-Term Moderate-Intensity Exercise Increases Growth Hormone Levels in Individuals with Obesity

Muhammad[1ABDE], Gigih Siantoro[1ABD], Irmantara Subagio[1ABD], Ghana Firsta Yosika[2BD], Yanyong Phanpheng[3CD], Bayu Agung Pramono[1BD], I Dewa Made Aryananda Wijaya Kusuma[1BD] and Adi Pranoto[4BCD]

[1]Universitas Negeri Surabaya
[2]Universitas Tanjungpura
[3]Loei Rajabhat University
[4]Universitas Airlangga

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

Corresponding Author: Muhammad, E-mail: muhammad@unesa.ac.id
Accepted for Publication: August 3, 2024
Published: August 30, 2024

DOI: 10.17309/tmfv.2024.4.14

Abstract

Objectives. This study aimed to analyze the effect of a four-week moderate-intensity exercise regimen on increasing growth hormone (GH) levels in individuals with obesity.

Materials and methods. A total of 25 female individuals aged 20-25 years, with a body mass index (BMI) of 27.50-37.00 kg/m^2, were involved in the study and randomly divided into two groups, namely the control group (CON; n = 12) and the moderate-intensity exercise group (MIE; n = 13). The moderate-intensity exercise regimen (treadmill exercise for 30 minutes at 60-70% of HRmax, and resistance exercise for 30 minutes at 60-70% of 1RM) was conducted 3 times per week for a period of 4 weeks. Blood samples from participants were collected pre- and post-exercise sessions, and GH levels were analyzed using the Enzyme-Linked Immunosorbent Assay method. Data analysis techniques used the paired sample t-test with a significance level of 5%.

Results. The paired sample t-test results of GH levels between the pre-exercise and post-exercise sessions in the CON group showed a change from (1291.79 ± 383.76 to 1151.53 ± 484.80 pg/mL; p = 0.694), while the MIE group demonstrated the following dynamics of change — from (1161.79 ± 133.72 to 2103.83 ± 357.09 pg/mL; p = 0.006).

Conclusions. The main findings of this study revealed that after implementing a four-week moderate-intensity exercise intervention, a significant increase in GH levels was observed in obese females.

Keywords: growth hormone, healthy lifestyle, obesity, physical exercise.

Introduction

Obesity, widely recognized as one of the greatest public health challenges of the modern era, continues to rise in prevalence worldwide (Alebna et al., 2024). The primary factors contributing to this condition include a sedentary lifestyle and a deficit in physical activity, often associated with an unsupportive environmental factor (Aljabri, 2022). Research has shown that a lifestyle with minimal movement has a significant impact on the increase in obesity cases, marked by a deterioration of metabolic function (Chen et al., 2024a). The lack of physical activity affects about 27.5 % of the global population, with the figure increasing to 42.3 % in high-income countries, contributing substantially to the global disease burden (Chen et al., 2024b; Guthold et al., 2018). Sedentary behavior, defined as activities with an energy expenditure of less than 1.5 metabolic equivalents (METs) during waking periods, represents the lowest level of physical activity and has been associated with increased fat mass and waist circumference, as demonstrated by significant statistical correlations (Zhang & Liu, 2024; Myers et al., 2016). Since 1990, the prevalence of obesity in adults has more than doubled, and in adolescents, it has quadrupled, with 2.5 billion adults overweight in 2022, including 890 million suffering from obesity, and more than

390 million children and adolescents also overweight, of which 160 million are obese (WHO, 2024). The significant increase in the number of children and adolescents who are overweight and obese, along with the drastic surge in obesity cases among adults and adolescents since 1990, affirms that obesity has evolved into a serious and urgent global health issue (Pranoto et al., 2024).

Obesity is often associated with various cardiometabolic comorbidities, including metabolic syndrome, prediabetes, type 2 diabetes mellitus, atherogenic dyslipidemia, and steatotic liver disease related to metabolic dysfunction, all of which are established risk factors for coronary heart disease, heart failure, and stroke (Petersen et al., 2024). Sedentary behavior is significantly related to weight gain and substantial metabolic disturbances, including the body's inability to effectively control blood sugar and blood pressure levels, as well as a decrease in fat breakdown efficiency (Gonzalez Ramirez & Bolaños Muñoz, 2023). This unhealthy metabolic status can trigger various pathophysiological changes in the body, including blood pressure, glucose tolerance, and lipid profile (Sun et al., 2023). These metabolic disorders can also be characterized by decreased levels of Growth Hormone (GH) and an increase in body fat that occurs in obesity (Hjelholt et al., 2020). The relationship between adipose tissue and GH secretion is complex (Salvatori et al., 2015). Obesity causes hyperinsulinemia, hypoadiponectinemia, hyperleptinemia, decreased serum ghrelin, and increased free fatty acid (FFA) levels, thereby suppressing GH secretion from the pituitary (Savastano et al., 2014). GH, often referred to as the 'master hormone,' plays a key role in regulating metabolic homeostasis and has multifaceted effects on various physiological processes (Al-Samerria & Radovick, 2023).

Physical activity is considered a fundamental foundation in the management of overweight and obesity (Oppert et al., 2021). Many benefits of physical activity can be obtained from an average of 60 minutes of moderate to high-intensity physical activity every day, and exceeding this duration can yield additional health benefits (Bull et al., 2020). Research by Ashcroft et al. (2024) indicates that physiological adjustments that occur simultaneously in various tissues in response to physical activity, and the synergistic interactions between these tissues, contribute to improved cardiometabolic health. Metabolic fitness refers to the body's ability to efficiently utilize energy, regulate blood sugar levels, and maintain overall health. It is associated with a reduced risk of non-communicable diseases and mortality (Sabag et al., 2021). GH is known to play a crucial role in physiological processes such as metabolism, tissue repair, and growth, and provides direct and indirect effects on adipose tissue (Carrard et al., 2021). Furthermore, although both aerobic and resistance exercises trigger Growth Hormone (GH) responses, the relative contribution of aerobic exercise to these GH responses and actions is arguably less clear (Sabag et al., 2021). Therefore, this study aims to analyze the influence of four weeks of moderate-intensity training on increasing GH levels in individuals with obesity.

Materials and Methods

Study Participants

A total of 25 young women who were obese were recruited voluntarily to participate in this study. Participants were randomly divided into two groups: a control group (CON; n = 12), and a moderate-intensity exercise group (MIE; n = 13). All participants received detailed information about the objectives, content, methods (exercise protocol and growth hormone function), and potential risk factors associated with the experimental design. The participants also consciously filled out and signed an Informed Consent Form. This study was conducted in accordance with the principles outlined in the Declaration of Helsinki and had received approval from the Health Research Ethics Commission (KEPK), Faculty of Medicine, Ciputra University (Indonesia) (No:103/EC/KEPK-FKUC/II/2024).

Study Design

The intervention applied in the study was moderate-intensity exercise (treadmill exercise for 30 minutes between 60-70 % of HRmax, and resistance exercise for 30 minutes between 60-70 % of 1RM), with a frequency of 3 times per week for 4 weeks. Meanwhile, the control group did not receive any form of intervention. Blood samples from participants were collected pre-exercise (before MIE) and post-exercise (after 4 weeks of MIE) from the cubital vein, amounting to 2ml, performed in the morning (08.00-10.00). GH levels were analyzed using Human Enzyme-Linked Immunosorbent Assay (ELISA) Kits (Cat.No.:E-EL-H0177; Elabscience Bionovation Inc., USA). The ELISA Kits used had been validated in previous research (Pranoto et al., 2024).

Statistical Analysis

Data analysis techniques were applied using the Shapiro–Wilk test for normality, while the paired sample t-test was used to determine differences in GH levels pre-exercise and post-exercise within each group. Meanwhile, the independent sample t-test was applied to determine differences in serum GH levels of the CON and MIE groups pre-, post-exercise, delta (pre-post), and change. The level of significance was accepted if $p \leq 0.05$.

Results

As indicated in Table 1, the values of systolic blood pressure, diastolic blood pressure, resting heart rate, oxygen saturation, body temperature, age, body weight, body height, and body mass index showed no significant differences between the two groups. Meanwhile, the results of the analysis of indicators of changes for blood pressure, resting heart rate, and body weight are presented in Table 2.

As illustrated in Fig. 1, the GH levels between pre-exercise and post-exercise in the CON group (from 1291.79 ± 383.76 to 1151.53 ± 484.80 pg/mL; $p = 0.694$) and the MIE group (from 1161.79 ± 133.72 to 2103.83 ± 357.09 pg/mL; $p = 0.006$) are presented. Figure 2 displays the GH levels between the CON and MIE groups at pre-exercise (from 1291.79 ± 383.76 to 1161.79 ± 133.72 pg/mL; $p = 0.744$), post-exercise (from 1151.53 ± 484.80 to 2103.83 ± 357.09 pg/mL; $p = 0.016$), delta (from -140.27 ± 347.62 to 942.03 ± 280.66 pg/mL; $p = 0.023$), and change (from -6.91 ± 13.83 to 80.07 ± 22.88%; $p = 0.004$).

Discussion

This study aimed to analyze the effect of a four-week combined exercise regimen on increasing GH levels in

Table 1. General population description in study

Parameters	Unit	CON; n = 12	MIE; n = 13	p
Systolic blood pressure	mmHg	111.50 ± 6.36	114.54 ± 7.87	0.302
Diastolic blood pressure	mmHg	75.92 ± 5.82	79.31 ± 5.62	0.152
Resting heart rate	bpm	72.83 ± 5.48	74.39 ± 5.44	0.485
Oxygen saturation	%	97.83 ± 1.27	97.62 ± 1.19	0.662
Body temperature	°C	36.08 ± 0.33	36.12 ± 0.25	0.737
Age	yrs	21.92 ± 1.31	21.62 ± 1.45	0.592
Body weight	kg	76.46 ± 9.65	76.45 ± 9.80	0.999
Body height	m	1.57 ± 0.06	1.55 ± 0.06	0.466
Body mass index	kg/m^2	30.66 ± 3.06	31.78 ± 3.24	0.384

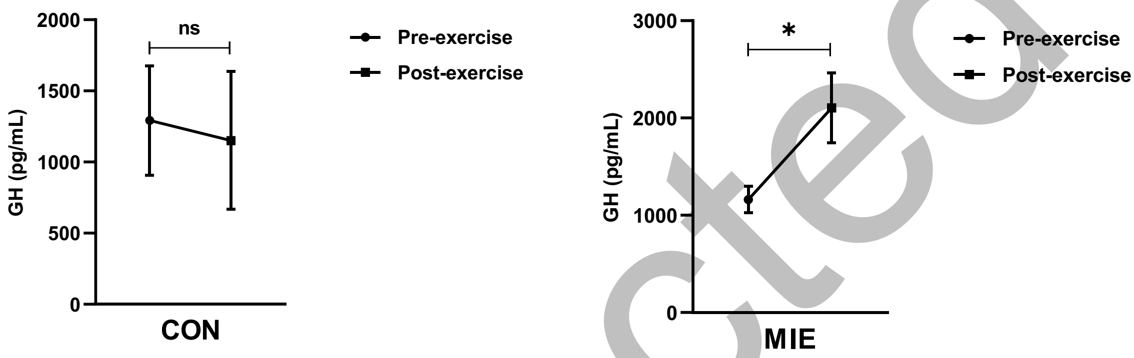

Fig. 1. Comparison of GH levels of both groups (CON and MIE) pre-exercise and post-exercise. *p ≤ 0.05, ns: Not significant, CON: Control group, MIE: Moderate-intensity exercise group, GH: Growth hormone

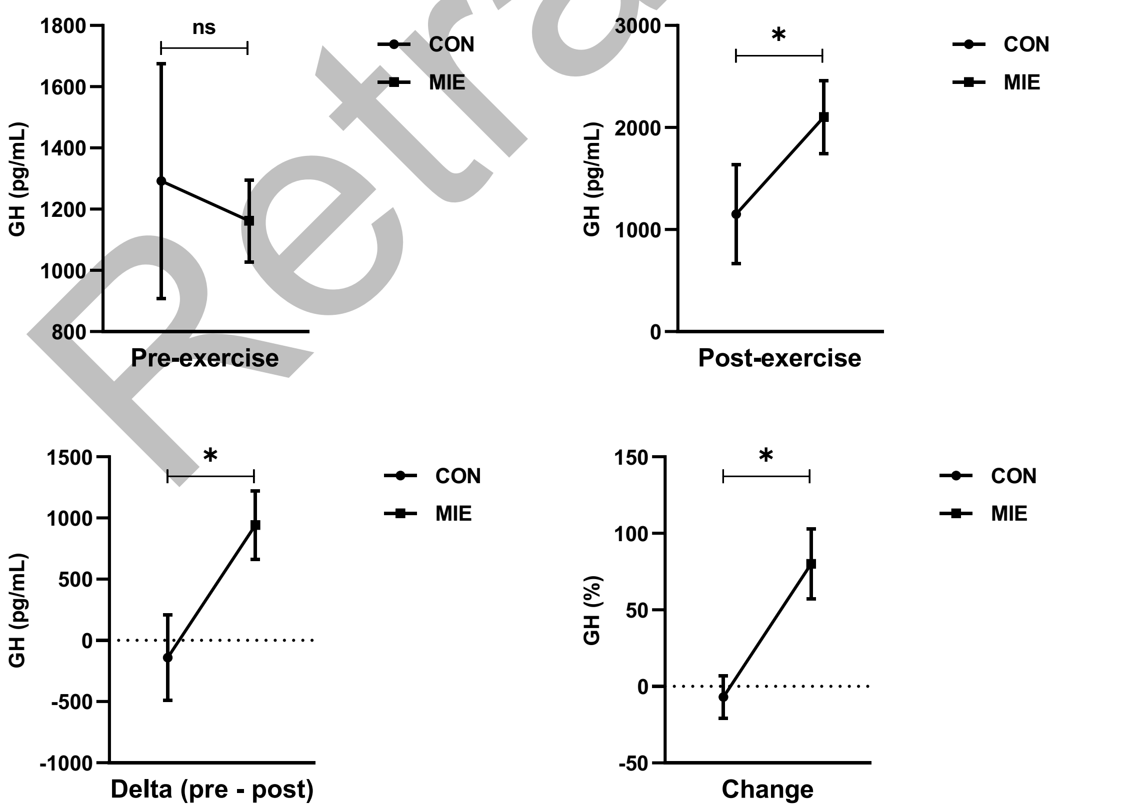

Fig. 2. Serum GH levels of CON and MIE groups pre-, post-execise, delta (pre-post), and change. *p ≤ 0.05, ns: Not significant, CON: Control group, MIE: Moderate-intensity exercise group, GH: Growth hormone

Table 2. Indicators of changes for blood pressure, resting heart rate, and body weight

Parameters	Unit	CON; n = 12	MIE; n = 13	p
Pre-SBP	mmHg	111.50 ± 6.36	114.54 ± 7.87	0.302
Post-SBP	mmHg	112.75 ± 4.88	111.31 ± 4.61	0.455
Changes-SBP	mmHg	1.25 ± 3.31	-3.23 ± 4.73*	0.012
Pre-DBP	mmHg	75.92 ± 5.82	79.31 ± 5.62	0.152
Post-DBP	mmHg	75.67 ± 4.96	76.23 ± 5.28	0.786
Changes-DBP	mmHg	-0.25 ± 2.83	-3.08 ± 1.26*	0.003
Pre-RHR	bpm	72.83 ± 5.48	74.39 ± 5.44	0.485
Post-RHR	bpm	72.75 ± 4.39	72.54 ± 5.29	0.915
Changes-RHR	bpm	-0.08 ± 2.71	-1.85 ± 0.80*	0.035
Pre-BW	kg	76.46 ± 9.65	76.45 ± 9.80	0.999
Post-BW	kg	76.61 ± 9.85	74.68 ± 9.32	0.622
Changes-BW	kg	0.15 ± 1.14	-1.77 ± 0.64*	0.000

Description: BW: Body weight; DBP: Diastolic blood pressure; SBP: Systolic blood pressure; RHR: Resting heart rate. *$p \leq 0.05$

obese women. The findings indicate a significant increase in GH levels, affirming the potential of combined exercise as an effective intervention. This positive correlation strengthens previous findings by Sabag et al. (2021), which also documented an increase in GH post-combined exercise. Furthermore, the study by Mendonça et al. (2022) provides consistent evidence, reinforcing the view that combined exercise contributes to increased GH levels. GH has therapeutic potential due to its strong lipolytic effects and the resulting ability to reduce fat mass while maintaining lean body mass (Berryman & List, 2017).

Combined exercise plays a key role in enhancing basal metabolism and lipolysis through the induction of intense muscle contractions, as explained by Muscella et al. (2020). This mechanism is reinforced by findings from Donato et al. (2021), which show that GH-responsive neurons are widespread in various brain areas that control metabolism, with a particular focus on the hypothalamic nuclei. This response is further elaborated by Hymer & Kraemer (2023), who identified that exercise stimulates the hypothalamus to release Growth Hormone-Releasing Hormone (GHRH), which then prompts the anterior pituitary gland to release GH into circulation. Additionally, O'Neill et al. (2022) linked exercise to a reduction in blood glucose levels, which triggers GH release, demonstrating the body's adaptive mechanism to maintain glucose homeostasis.

Good metabolic health is a crucial aspect of obesity management, and physical exercise plays an important role in achieving it (Gergő Szűcs et al., 2023). Regular physical exercise can improve the metabolic profile of individuals with obesity in various ways (Liu et al., 2019). First, exercise increases insulin sensitivity, which is important for blood glucose regulation and the prevention of type 2 diabetes (Hsu et al., 2019). Second, physical activity helps reduce visceral fat, which is associated with an increased risk of cardiovascular disease (Oppert et al., 2023). Third, physical exercise promotes weight loss and the maintenance of a healthy weight, which is important for reducing the load on the musculoskeletal system and decreasing the risk of osteoarthritis (Richa et al., 2023). Fourth, physical exercise improves body composition by increasing muscle mass, which aids in calorie burning and maintaining a healthy metabolism (Liu et al., 2019). Fifth, physical exercise also plays a role in reducing oxidative stress and inflammation, both of which contribute to the pathogenesis of obesity and its comorbidities (Gergő Szűcs et al., 2023). Therefore, integrating physical exercise into daily life is an effective strategy for improving metabolic health and reducing the risk of obesity-related diseases (Liu et al., 2019).

Combined exercise, which incorporates aerobic and anaerobic elements, has been proven effective in increasing GH levels in obese women (Davis et al., 2024). GH plays a vital role in metabolism regulation, including stimulating lipolysis and energy production (Davis et al., 2022). In individuals with obesity, increasing GH levels through combined exercise can help overcome the GH resistance often seen in obesity, contributing to decreased metabolic efficiency (Foster-Schubert et al., 2011). By increasing GH levels, combined exercise not only aids in body fat reduction but also promotes protein synthesis and muscle growth, which are important for enhancing the basal metabolic rate (Liang et al., 2021). These benefits, when combined, can result in a comprehensive improvement in metabolic health, which is crucial for long-term obesity management and quality of life enhancement (Mousa Khalafi et al., 2024). Therefore, combined exercise should be considered a valuable intervention strategy in obesity management programs for women (Davis et al., 2024). It can be concluded from this study that four weeks of combined exercise significantly increases GH levels in obese women. This study has several limitations that need to be considered. First, the study duration of only four weeks may not be sufficient to observe the long-term effects of combined exercise on GH levels. Second, the study sample was limited to obese women, so the results may not be generalizable to other populations such as men or individuals with normal weight. Third, this study did not consider other factors that may affect GH levels, such as diet, sleep quality, and stress. The findings from this study provide important clinical implications. Increasing GH levels through combined exercise could be a potential therapeutic strategy for improving the metabolic profile in obese women. This suggests that combined exercise could be integrated into obesity management programs to improve metabolic health and reduce the risk of comorbidities associated with obesity. Future research should be designed to address the limitations of this study. Longer-duration studies are needed to assess the long-term effects of combined exercise on GH levels and other health components. Additionally, studies with larger and more diverse samples will help understand the effects of combined exercise on a broader population. Further research is also needed to explore the interactions between combined exercise and factors such as diet and sleep patterns in regulating GH levels.

Conclusion

Specifically, this study found an increase in GH levels after a four-week intervention of moderate-intensity exercise in obese women. The results of this study can be taken into account in planning training programs for individuals with obesity.

Conflict of Interest

The authors declare no conflict of interest in this study.

References

Alebna, P. L., Mehta, A., Yehya, A., daSilva-deAbreu, A., Lavie, C. J., & Carbone, S. (2024). Update on obesity, the obesity paradox, and obesity management in heart failure. *Progress in cardiovascular diseases,* 82, 34-42. https://doi.org/10.1016/j.pcad.2024.01.003

Aljabri D. (2022). Associations Between Obesity, Physical Inactivity, Healthcare Capacity, and the Built Environment: Geographic Information System Analysis. *Journal of multidisciplinary healthcare,* 15, 689-704. https://doi.org/10.2147/JMDH.S345458

Chen, J., Ruan, X., Fu, T., Lu, S., Gill, D., He, Z., Burgess, S., Giovannucci, E. L., Larsson, S. C., Deng, M., Yuan, S., & Li, X. (2024a). Sedentary lifestyle, physical activity, and gastrointestinal diseases: evidence from mendelian randomization analysis. *EBioMedicine,* 103, 105110. Advance online publication. https://doi.org/10.1016/j.ebiom.2024.105110

Chen, S., Yang, L., Yang, Y., Shi, W., Stults-Kolehmainen, M., Yuan, Q., Wang, C., & Ye, J. (2024b). Sedentary behavior, physical activity, sleep duration and obesity risk: Mendelian randomization study. *PloS One, 19*(3), e0300074–e0300074. https://doi.org/10.1371/journal.pone.0300074

Guthold, R., Stevens, G. A., Riley, L. M., & Bull, F. C. (2018). Worldwide trends in insufficient physical activity from 2001 to 2016: a pooled analysis of 358 population-based surveys with 1·9 million participants. The Lancet. *Global health, 6*(10), e1077–e1086. https://doi.org/10.1016/S2214-109X(18)30357-7

Zhang, Y., & Liu, X. (2024). Effects of physical activity and sedentary behaviors on cardiovascular disease and the risk of all-cause mortality in overweight or obese middle-aged and older adults. *Frontiers in public health,* 12, 1302783. https://doi.org/10.3389/fpubh.2024.1302783

Myers, A., Gibbons, C., Finlayson, G., & Blundell, J. (2016). Associations among sedentary and active behaviours, body fat and appetite dysregulation: investigating the myth of physical inactivity and obesity. *British Journal of Sports Medicine, 51*(21), 1540-1544. https://doi.org/10.1136/bjsports-2015-095640

World Health Organization (WHO). (2024, March 1). *Obesity and Overweight.* World Health Organization. https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight.

Pranoto, A., Rejeki, P. S., Miftahussurur, M., Yosika, G. F., Ihsan, M., Herawati, L., Rahmanto, I., & Halim, S. (2024). Aerobic Exercise Increases Release of Growth Hormone in the Blood Circulation in Obese Women. *Retos,* 51, 726-731. https://doi.org/10.47197/retos.v51.99944

Petersen, M. C., Smith, G. I., Palacios, H. H., Farabi, S. S., Yoshino, M., Yoshino, J., Cho, K., Davila-Roman, V. G., Shankaran, M., Barve, R. A., Yu, J., Stern, J. H., Patterson, B. W., Hellerstein, M. K., Shulman, G. I., Patti, G. J., & Klein, S. (2024). Cardiometabolic characteristics of people with metabolically healthy and unhealthy obesity. *Cell metabolism, 36*(4), 745-761.e5. https://doi.org/10.1016/j.cmet.2024.03.002

Gonzalez Ramirez, G. & Bolaños Muñoz, L. (2023). Relationship of Sedentary Lifestyle with Obesity and Comorbidities. In: Ruiz-Tovar, J., Marc-Hernandez, A. (eds) P*hysical Activity and Bariatric Surgery.* Springer, Cham. https://doi.org/10.1007/978-3-031-26614-0_1

Sun, M., Fritz, J., Häggström, C., Bjørge, T., Nagel, G., Manjer, J., Engeland, A., Zitt, E., van Guelpen, B., Stattin, P., Ulmer, H., & Stocks, T. (2023). Metabolically (un)healthy obesity and risk of obesity-related cancers: a pooled study. *Journal of the National Cancer Institute, 115*(4), 456-467. https://doi.org/10.1093/jnci/djad008

Hjelholt, A., Høgild, M., Bak, A. M., Arlien-Søborg, M. C., Bæk, A., Jessen, N., Richelsen, B., Pedersen, S. B., Møller, N., & Lunde Jørgensen, J. O. (2020). Growth Hormone and Obesity. *Endocrinology and metabolism clinics of North America, 49*(2), 239-250. https://doi.org/10.1016/j.ecl.2020.02.009

Salvatori R. (2015). Growth hormone deficiency in patients with obesity. *Endocrine, 49*(2), 304-306. https://doi.org/10.1007/s12020-015-0571-4

Savastano, S., Di Somma, C., Barrea, L., & Colao, A. (2014). The complex relationship between obesity and the somatropic axis: The long and winding road. *Growth Hormone & IGF Research, 24*(6), 221–226. https://doi.org/10.1016/j.ghir.2014.09.002

Al-Samerria, S., & Radovick, S. (2023). Exploring the Therapeutic Potential of Targeting GH and IGF-1 in the Management of Obesity: Insights from the Interplay between These Hormones and Metabolism. *International journal of molecular sciences, 24*(11), 9556. https://doi.org/10.3390/ijms24119556

Oppert, J., Bellicha, A., Van Baak, M. A., Battista, F., Beaulieu, K., Blundell, J. E., Carraça, E. V., Encantado, J., Ermolao, A., Pramono, A., Farpour-Lambert, N., Woodward, E., Dicker, D., & Busetto, L. (2021). Exercise training in the management of overweight and obesity in adults: Synthesis of the evidence and recommendations from the European Association for the Study of Obesity Physical Activity Working Group. *Obesity Reviews, 22*(S4), e13273. https://doi.org/10.1111/obr.13273

Bull, F. C., Al-Ansari, S. S., Biddle, S., Borodulin, K., Buman, M. P., Cardon, G., Carty, C., Chaput, J. P., Chastin, S., Chou, R., Dempsey, P. C., DiPietro, L., Ekelund, U., Firth, J., Friedenreich, C. M., Garcia, L., Gichu, M., Jago, R., Katzmarzyk, P. T., Lambert, E., … Willumsen, J. F. (2020). World Health Organization 2020 guidelines on physical activity and sedentary behaviour. *British journal of sports medicine, 54*(24), 1451-1462. https://doi.org/10.1136/bjsports-2020-102955

Ashcroft, S. P., Stocks, B., Egan, B., & Zierath, J. R. (2024). Exercise induces tissue-specific adaptations to enhance cardiometabolic health. *Cell metabolism, 36*(2), 278-300. https://doi.org/10.1016/j.cmet.2023.12.008

Sabag, A., Chang, D., & Johnson, N. A. (2021). Growth Hormone as a Potential Mediator of Aerobic Exercise-Induced Reductions in Visceral Adipose Tissue. *Frontiers in physiology,* 12, 623570. https://doi.org/10.3389/fphys.2021.623570

Carrard, J., Guerini, C., Appenzeller-Herzog, C., Infanger, D., Karsten Königstein, Lukas Streese, Hinrichs, T., Hanssen, H., Gallart-Ayala, H., Julijana Ivanisevic, & Arno Schmidt-Trucksäss. (2021). The Metabolic Signature of Cardiorespiratory Fitness: A Systematic Review. *Sports Medicine, 52*(3), 527-546. https://doi.org/10.1007/s40279-021-01590-y

Mendonça, F. R., Ferreira de Faria, W., Marcio da Silva, J., Massuto, R. B., Castilho Dos Santos, G., Correa, R. C., Ferreira Dos Santos, C., Sasaki, J. E., & Neto, A. S. (2022). Effects of aerobic exercise combined with resistance training on health-related physical fitness in adolescents: A randomized controlled trial. *Journal of exercise science and fitness, 20*(2), 182-189. https://doi.org/10.1016/j.jesf.2022.03.002

Berryman, D., & List, E. (2017). Growth Hormone's Effect on Adipose Tissue: Quality versus Quantity. *International Journal of Molecular Sciences, 18*(8), 1621. https://doi.org/10.3390/ijms18081621

Muscella, A., Stefàno, E., Lunetti, P., Capobianco, L., & Marsigliante, S. (2020). The Regulation of Fat Metabolism During Aerobic Exercise. *Biomolecules, 10*(12), 1699. https://doi.org/10.3390/biom10121699

Donato, J., Jr, Wasinski, F., Furigo, I. C., Metzger, M., & Frazão, R. (2021). Central Regulation of Metabolism by Growth Hormone. *Cells, 10*(1), 129. https://doi.org/10.3390/cells10010129

Hymer, W. C., & Kraemer, W. J. (2023). Resistance exercise stress: theoretical mechanisms for growth hormone processing and release from the anterior pituitary somatotroph. *European Journal of Applied Physiology, 123*(9), 1867-1878. https://doi.org/10.1007/s00421-023-05263-8

O'Neill, C. C., Locke, E. J., Sipf, D. A., Thompson, J. H., Drebushenko, E. K., Berger, N. S., Segich, B. S., & Kolwicz, S. C., Jr (2022). The Effects of Exercise Training on Glucose Homeostasis and Muscle Metabolism in Type 1 Diabetic Female Mice. *Metabolites, 12*(10), 948. https://doi.org/10.3390/metabo12100948

Gergő Szűcs, Márton Pipicz, Szabó, M., Tamás Csont, László Török, & Csonka, C. (2023). Effect of Eccentric Exercise on Metabolic Health in Diabetes and Obesity. *Sports Medicine - Open, 9*(1). https://doi.org/10.1186/s40798-023-00596-2

Liu, S., Niu, Y., & Fu, L. (2019). Metabolic Adaptations to Exercise Training. *Journal of Science in Sport and Exercise, 2*(1), 1-6. https://doi.org/10.1007/s42978-019-0018-3

Hsu, K.-J., Liao, C.-D., Tsai, M.-W., & Chen, C.-N. (2019). Effects of Exercise and Nutritional Intervention on Body Composition, Metabolic Health, and Physical Performance in Adults with Sarcopenic Obesity: A Meta-Analysis. *Nutrients, 11*(9). https://doi.org/10.3390/nu11092163

Oppert, J.-M., Ciangura, C., & Bellicha, A. (2023). Physical activity and exercise for weight loss and maintenance in people living with obesity. *Reviews in Endocrine and Metabolic Disorders,* 24. https://doi.org/10.1007/s11154-023-09805-5

Rai, R. H., Singh, R. B., Mehta, V., Sakshi, Asif, M., Goyal, K., Balodhi, A., Manglik, P., Sharma, A., & Chahal, A. (2023). Impact of exercise training duration on obesity and cardiometabolic biomarkers: A systematic review. *Journal of Diabetes & Metabolic Disorders, 22*(1), 155-174. https://doi.org/10.1007/s40200-023-01219-z

Davis, M. E., Blake, C., & O'Donoghue, G. (2024). Comparison of time-matched aerobic, resistance or combined exercise training in women living with obesity: The EXOFFIT study. *Obesity science & practice, 10*(2), e749. https://doi.org/10.1002/osp4.749

Davis, M. E., Blake, C., Cunningham, C., Carson, B. P., & O'Donoghue, G. (2022). Comparison of time-matched aerobic, resistance or combined exercise training in women living with obesity: a protocol for a pilot randomised controlled trial—the EXOFFIT (Exercise for Obesity in Females to increase Fitness) study. *Pilot and Feasibility Studies, 8*(1). https://doi.org/10.1186/s40814-022-01003-5

Foster-Schubert, K. E., Alfano, C. M., Duggan, C. R., Xiao, L., Campbell, K. L., Kong, A., Bain, C. E., Wang, C.-Y., Blackburn, G. L., & McTiernan, A. (2011). Effect of Diet and Exercise, Alone or Combined, on Weight and Body Composition in Overweight-to-Obese Postmenopausal Women. *Obesity, 20*(8), 1628-1638. https://doi.org/10.1038/oby.2011.76

Liang, M., Pan, Y., Zhong, T., Zeng, Y., & Cheng, A. S.K. (2021). Effects of aerobic, resistance, and combined exercise on metabolic syndrome parameters and cardiovascular risk factors: a systematic review and network meta-analysis. *Reviews in Cardiovascular Medicine, 22*(4), 1523. https://doi.org/10.31083/j.rcm2204156

Mousa Khalafi, Symonds, M., Aref Habibi Maleki, Mohammad Hossein Sakhaei, Mahsa Ehsanifar, & Rosenkranz, S. K. (2024). Combined versus independent effects of exercise training and intermittent fasting on body composition and cardiometabolic health in adults: a systematic review and meta-analysis. *Nutrition Journal, 23*(1). https://doi.org/10.1186/s12937-023-00909-x

Заняття короткотривалими фізичними вправами помірної інтенсивності підвищують рівень гормону росту в осіб з ожирінням

Мухаммад[1ABDE], Гігіх Сіанторо[1ABD], Ірмантара Субагіо[1ABD], Гхана Фірста Йосіка[2BD], Яньон Пханпхен[3CD], Баю Агун Прамоно[1BD], І Дева Маде Арянанда Віджая Кусума[1BD], Аді Праното[4BCD]

[1]Сурабайський державний університет
[2]Університет Танджунгпура
[3]Лоейський університет Раджабхат
[4]Університет Айрланга

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

Реферат. Стаття: 7 с., 2 табл., 2 рис., 37 джерел.

Мета дослідження. Мета цього дослідження полягала в аналізі впливу застосування чотиритижневого режиму фізичних вправ помірної інтенсивності на підвищення рівня гормону росту (ГР) в осіб з ожирінням.

Матеріали та методи. У дослідженні взяли участь 25 осіб жіночої статі віком 20-25 років з індексом маси тіла (ІМТ) 27,50-37,00 кг/м^2, які були розподілені за методом рандомізації на дві групи: контрольну (КОН; n = 12) та групу тренувань помірної інтенсивності (ТПІ; n = 13). Режим фізичних вправ помірної інтенсивності (тренування на біговій доріжці протягом 30 хвилин на рівні 60-70% від максимальної частоти серцевих скорочень (ЧСС макс.) та вправи з опором протягом 30 хвилин на рівні 60-70% від показника максимуму одного повторення або 1ПМ — вказує на максимальну вагу, яку можна підняти з максимальним зусиллям за одне повторення) проводили 3 рази на тиждень впродовж 4-тижневого періоду. В учасників дослідження відбирали зразки крові перед початком і після закінчення тренувань, а рівень гормону росту визначали за допомогою методу ферментного імуносорбентного аналізу. Під час аналізу даних використовувався t-критерій для парних вибірок з рівнем значущості 5%.

Результати. Результати t-критерію для парних вибірок рівнів гормону росту між сеансами перед та після проведення тренування в контрольній групі показали змінення з (1291,79 ± 383,76 до 1151,53 ± 484,80 пг/мл; p = 0,694), в той час як група тренувань помірної інтенсивності продемонструвала таку динаміку змінення — з (1161,79 ± 133,72 до 2103,83 ± 357,09 пг/мл; p = 0,006).

Висновки. Згідно з ключовими висновками цього дослідження встановлено, що після впровадження інтервенції у вигляді комплексу фізичних вправ помірної інтенсивності впродовж чотирьох тижнів у жінок з ожирінням спостерігалося значне підвищення рівня гормону росту.

Ключові слова: гормон росту, здоровий спосіб життя, ожиріння, фізичні вправи.

Information about the authors:

Muhammad: muhammad@unesa.ac.id; https://orcid.org/0000-0002-6735-1425; Department of Sport Coaching Education, Faculty of Sport and Health Science, Universitas Negeri Surabaya, Jl. Lidah Wetan, Lidah Wetan, Kec. Lakarsantri, Kota SBY, Jawa Timur 60213, Indonesia.

Siantoro, Gigih: gigihsiantoro@unesa.ac.id; https://orcid.org/0009-0000-4377-5218; Department of Sport Coaching Education, Faculty of Sports and Health Sciences, Universitas Negeri Surabaya, Jl. Lidah Wetan, Lidah Wetan, Kec. Lakarsantri, Kota SBY, Jawa Timur 60213, Indonesia.

Subagio, Irmantara: irmantarasubagio@unesa.ac.id; https://orcid.org/0000-0003-0265-7842; Department of Sport Coaching Education, Faculty of Sport and Health Science, Universitas Negeri Surabaya, Jl. Lidah Wetan, Lidah Wetan, Kec. Lakarsantri, Kota SBY, Jawa Timur 60213, Indonesia.

Yosika, Ghana Firsta: gfyosika@gmail.com; https://orcid.org/0000-0002-9993-7586; Study Program of Sports Coaching Education, Faculty of Teacher Training and Education, Tanjungpura University, Prof. Dr. H. Hadari Nawawi Street, Pontianak, West Kalimantan 78124, Indonesia.

Phanpheng, Yanyong: yanyong.pha@lru.ac.th; https://orcid.org/0000-0002-9290-2479; Sports and Exercise Science Program, Faculty of Science and Technology, Loei Rajabhat University, 234 Loei - Chiang Khan Road, Loei 42000, Thailand.

Pramono, Bayu Agung: bayupramono@unesa.ac.id; https://orcid.org/0000-0002-9308-1289; Department of Sport Coaching Education, Universitas Negeri Surabaya, Jl. Lidah Wetan, Lidah Wetan, Kec. Lakarsantri, Kota SBY, Jawa Timur 60213, Indonesia.

Kusuma, I Dewa Made Aryananda Wijaya: dewawijaya@unesa.ac.id; https://orcid.org/0000-0002-4939-7294; Department of Sport Coaching Education, Universitas Negeri Surabaya, Jl. Lidah Wetan, Lidah Wetan, Kec. Lakarsantri, Kota SBY, Jawa Timur 60213, 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.

Cite this article as: Muhammad, Siantoro, G., Subagio, I., Yosika, G. F., Phanpheng, Y., Pramono, B. A., Kusuma, I. D. M. A. W., & Pranoto, A. (2024). Engaging in Short-Term Moderate-Intensity Exercise Increases Growth Hormone Levels in Individuals with Obesity. *Physical Education Theory and Methodology, 24*(4), 619-625. https://doi.org/10.17309/tmfv.2024.4.14

Received: 16.05.2024. Accepted: 26.07.2024. Published: 30.08.2024

Retraction Note

The Editors have retracted the following article:

Muhammad, Siantoro, G., Subagio, I., Yosika, G. F., Phanpheng, Y., Pramono, B. A., Kusuma, I. D. M. A. W., & Pranoto, A. (2024). Engaging in Short-Term Moderate-Intensity Exercise Increases Growth Hormone Levels in Individuals with Obesity. *Physical Education Theory and Methodology*, *24*(4), 619–625. https://doi.org/10.17309/tmfv.2024.4.14

The Editors retract this article due to identified errors in citation. The authors did not consent to the retraction of the article.

We have been informed in our decision-making by our policy on publishing ethics and COPE guidelines.

The retracted article will remain online to maintain the scholarly record, but it will be digitally watermarked on each page as "Retracted".