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Original Article

High-intensity interval training improves physical performance without C-reactive protein (CRP) level alteration in overweight sedentary women

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Abstract

A sedentary lifestyle is associated with an unhealthy diet and lack of physical activity. This study aimed to analyze the effect of high-intensity interval training (HIIT) on changes in VO2max and C-reactive protein (CRP) levels in overweight young adult women with a sedentary lifestyle. The subjects included 20 women who were 21–30 years old and divided into 2 groups, a treatment group (performed HIIT) and a control group. Physical exercise (bicycle) included an intensity of 90% of the maximum heart rate (HRmax) with intervals. The exercise was carried out by pedaling an ergocycle for 10 s at a speed of 100 rpm and 50 s at a speed of 50 rpm intermittently for a total of 20 min. Exercise was performed 3×/week or 8 sessions in 3 weeks. The measured variables included VO2max and CRP level. These were taken before (pre) and after (post) treatment. VO2max was measured by the Astrand–Rhyming Test with a bicycle ergometer, and CRP was analyzed using the ELISA method. In addition, the changes in VO2max and CRP levels were also calculated. These results showed that the VO2max after treatment with HIIT (35.2±2.12 ml/kg/min) was significantly higher ($p<0.05$) compared to the control (28.9±2.58 ml/kg/min). The CRP levels (ng/mL) in the control was increased, and it tended to decrease with HIIT; however, this difference was not significant ($p\geq0.05$). This study concludes that bicycling HIIT can improve the VO2max and decrease the serum CRP level in overweight young adult women who lead a sedentary lifestyle.

Key Words*:* **HIIT, VO2max, CRP, bicycle, overweight, sedentary, healthy lifestyle**

Introduction

A sedentary lifestyle is associated with an unhealthy diet and lack of physical activity, which causes an increase in body fat accumulation and can increase several risk factors, such as dyslipidemia, overweightness, and obesity (Ma et al., 2019; Mamikutty et al., 2014; Moreno-Fernández et al., 2018; Rask Larsen et al., 2018; Sazali et al., 2021). This situation can trigger systemic inflammation or C-reactive protein (CRP) production in overweight individuals due to excess fat deposits in the tissues, which progressively increases the risks of cardiovascular disease (CVD) and type 2 diabetes mellitus (T2DM) (Kaur, 2014). People who are overweight/obese (BMI 25–29.9 kg/m^2) also tend to have increased CRP levels compared to normal people (BMI<25 kg/m^2) (Khoury et al., 2013). An overweight individual has high-fat accumulation, and it can lead to an increased production of oxidative stress (Susantiningsih, 2015) and increase the synthesis of pro-inflammatory cytokines, such as IL-6, TNF-α, and IL-1β. IL-6 is a major regulator of CRP synthesis and is amplified by IL-1β and TNF-α. These three cytokines will increase the transcription rate of CRP (As'ad et al., 2021; Salazar-Martínez et al., 2018). A sedentary lifestyle in overweight individuals can also cause declined function in the cardiovascular system and increase the risk of heart disease (Nuzzo, 2019).

In Indonesia, the prevalence of people who are overweight increased annually by 8.6% in 2007, 11.5% in 2013, and 13.6% in 2018, which occurred in both adults and children (Ministry of Health of Indonesia, 2018; Rahayu et al., 2019). Meanwhile, the obesity prevalence rate was 10.5% in 2007, 14.8% in 2013, and 21.8% in 2018 (Riskesdas, 2018). In addition, if the obesity cycle occurs repeatedly in the same individual and sarcopenia occurs, the risk factors for metabolic syndrome attacks will be higher (Ma et al.,2019). The main risk of metabolic syndrome is due to the role of sympathetic nervous system activation that contributes to improving

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vascular and cardiac function, which stimulates vasoconstriction in blood vessels, causing blood pressure to increase (Bastien *et al.*, 2014; Hall *et al.*, 2016). In addition, the metabolic balance is unstable, such as excess lipolysis, which can increase fatty acid levels so that it affects blood vessels and heart function (Ciccarelli *et al*., 2013). Thus, with pathological symptoms, in general, there is an increased blood pressure (hypertension), increased plasma triglycerides, plasma glucose, and insulin resistance, which causes an increased risk of heart disease, stroke, and diabetes (Han & Lean, 2016; Pescatello, 2014). These will have an impact on the overall quality of public health, which is becoming worse. One method that can solve this problem is a non-pharmacological approach, such as physical exercise. Physical exercise has been shown to improve cardiovascular fitness and health by decreasing pro-inflammatory status, which is the inducer of CRP synthesis (Palaparthi, 2017; Syamsudin et al., 2021). HIIT (High-Intensity Interval Training) is a physical exercise that combines high intensity and moderate/ low intensity intermittently (Stöggl & Björklund, 2017). According to Thompson (2019), HIIT is favored by the public as it has become the 3rd most popular type of physical exercise around the world. However, changes in CRP during HIIT interventions in some studies are still debated (García-Hermoso et al., 2016). According to Ramos et al. (2015) in a meta-analysis, a high-intensity exercise program for 2 weeks effectively affects cardiorespiratory function, CVD risk factors, oxidative stress, inflammation, and insulin sensitivity. Nonetheless, in one study (Nassis et al., 2005) conducted on 19 overweight and obese women, there was no change in CRP concentrations after 12 weeks of moderate-intensity aerobic training. Therefore, this study aimed to disclose and determine the effect of HIIT on physical fitness and CRP levels in overweight women with a sedentary lifestyle.

Materials & methods

This research received ethical approval from the Ethics Committee of the Medical Faculty, Airlangga University. The design of this study was a pretest–posttest control group design. There were two groups in this study, an experimental group (HIIT) that was treated with high-intensity physical exercise at intervals (HIIT) and a control group (CONT) without intervention. The research subjects were women who were categorized in the Asia Pacific body mass index (BMI) in the overweight category (BMI = 23–24.9) who were 21–30 years old and in the sedentary lifestyle category. The sample size in this study was 10 in each group. The HIIT protocol was high-intensity physical exercise, which is 90% of the maximum pulse rate (HRmax) performed at intervals using an ergocycle for 10 s at 100 rpm and 50 seconds at 50 rpm, which was performed intermittently for a total time of 20 min. Exercises was carried out 3×/week or 8 sessions in 3 weeks (Alansare et al., 2018).

The data in this study, which included VO2max and C-reactive protein (CRP) levels, were taken before (pre) and after (post) treatment. In addition, changes in VO2max and CRP were also observed, which were obtained from the calculation of the difference between data after and data before treatment. Measurement of VO2max using the Astrand–Rhyming Test was carried out using a bicycle ergometer. The unit for VO2max is mL/kgBW/min. CRP levels were analyzed using enzyme-linked immune absorbent assays (ELISA) using the reagent (hs-CRP) CAN-CRP-4360. The unit for CRP is ng/mL.

The data were analyzed using SPSS software and were analyzed descriptively. Furthermore, normality and homogeneity tests were carried out. The data were normally distributed and homogeneous, and then, a difference test between groups was performed using an independent T-test to determine the difference between pre- and post-data in the same group using a paired T-test.

Results

The data included VO2max in milliliters (mL) of oxygen consumption per kilogram (kg) of body weight per minute (minutes) (mL/kg/min) and C-reactive protein (CRP) in nanograms per milliliter (ng/mL). Data consisted of pre (before) intervention and post (after) intervention.

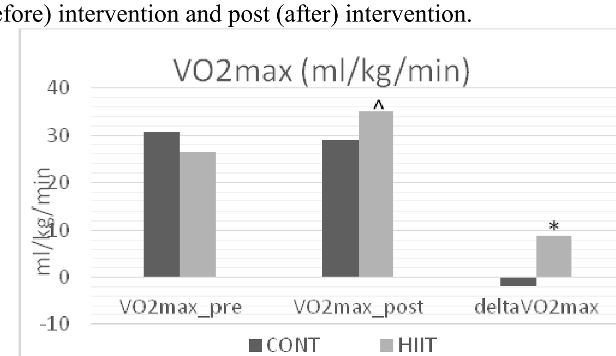

Figure 1. Mean of VO2max in mL/kg/min

VO2max_pre= before treatment; VO2max_post= after treatment; deltaVO2max= the change in VO2max.

CONT= control group; HIIT= high intensity interval training.

^sig. difference ($p<0.05$) compared to the pretest in the same group (paired T-test)

*sig. difference ($p<0.05$) compared to the control group (independent T-test)

Based on Figure 1. The results of the paired T-test in the HIIT group for the pretest–posttest showed that there was a significant difference in the VO2max value (p=0.00), while the control did not show a significant difference (p=0.038). In the Independent T-test, there was an increase in VO2max, which was not significant (p=0.08) for the HIIT group compared to the control with a high range.

Based on Figure 2. The results of the paired T-test for CRP levels in the pretest–posttest in the control and HIIT groups did not show a significant difference (p = 0.25; p = 0.13), but in the HIIT group, there were decreasing CRP levels, while the control levels tended to increase. Likewise, the Mann–Whitney test for delta CRP did not show a significant difference (p = 0.06); however, in the HIIT group, CRP levels decreased, while in the control group, there was an increase in CRP levels.

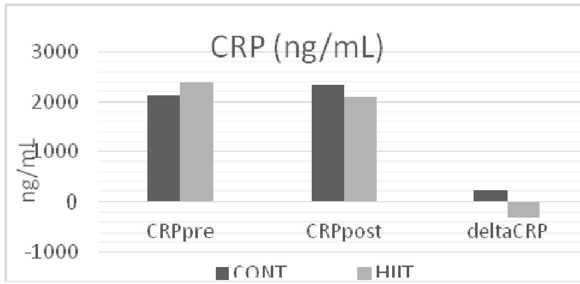

Figure 2. Mean of CRP in ng/mL
CRPpre= before treatment; CRPpost= after treatment; deltaCRP= the change in CRP.
CONT= control group; HIIT= high-intensity interval training
No significant difference (p≥0.05) between groups (independent T-test; Mann–Whitney test for deltaCRP) or between pre and post in the same group (paired T-test)

Table 1. Mean of all variables

Group	VO2max (mL/kg/min)		ΔVO2max (mL/kg/min)	CRP (ng/mL)		ΔCRP
	pre	post		pre	post	
Control	30.9±2.41	28.9±2.58^	-1.9±2.09[a]	2118.10±179.916	2349.92±110.166	231.82±190.307
HIIT	26.4±2.47	35.2±2.12	8.6±1.56[b]	2397.10±129.497	2097.84±177.832	-299.23±178.506

Data are presented as mean±SE; n=10 in each group. Statistical analyses included an independent T-test and paired T-test. Significant difference between pre & post (^). Significant difference between groups (different superscript).

Discussion

Based on the results above, an increase in VO2max occurred in the HIIT group, but the VO2max in the control group decreased. This is in line with a prior study (Astorino et al., 2012) where female and male subjects who were included in the active category completed 6 HIIT sessions for up to 3 weeks and there was a significant change in various parameters, including VO2max, from the baseline level at 43.6 to 46.0. According to Sloth et al. (2013), various HIIT protocols, such as sprint interval training (SIT), can also increase VO2max capacity to the range of 4.2–13.4%. This is because HIIT alters the function and structure of mitochondria and increases the transport of glucose, lactate, and fatty acid in skeletal muscle. These mitochondrial adaptations increase oxidative capacity and substrate availability in skeletal muscle, such as an increase of myoglobin, which improves VO2max (Hoshino et al., 2016).

Physical fitness can be determined with fitness component tests. Not only sedentary women, but all persons, including athletes, also need to determine their fitness level (Sanchez-garcía et al., 2022; Sovenko, 2022). One fitness component test is the cardiovascular endurance test or VO2max, which is defined as the ability of the lungs, heart, and blood vessels to deliver a certain amount of oxygen and nutrients to cells to fulfill energy needs for a long duration of physical activity. When a person breathes, some of the oxygen contained in the air is absorbed by the lungs and transported into the heart. Then, the heart is responsible for pumping oxygenated blood through the circulatory system to all organs and tissues of the body. At the cellular level, oxygen is used to convert food substances, especially carbohydrates and fats into energy, which is important for maintaining normal body functions (Setyo, 2012). The increase in VO2max during HIIT can occur due to an increase in oxygen availability due to a central effect on cardiac output; this is also influenced by peripheral adaptation with an increased ability to take up and use the available oxygen due to an increase in muscle oxidation potential.

There are various techniques, methods, and procedures that can be used to measure VO2max, e.g., using a bicycle (Astrand-Rhyming Test), treadmill (Astrand Treadmill Test), sitting bench (Step Test), or just running by determining the distance and then recording the time (Coper run test of 2.400 meters). However, because the subjects included in this study were overweight, the bicycle is better because it reduces the risk of injury (Hoeger et al., 2019).

Regarding the CRP result, clearly, there were lower CRP levels in the HIIT group, although there was no significant difference. On the other hand, in the control group, there was an increase from the baseline value. HIIT exercise adaptation in the HIIT group affected the level of inflammation. This is in line with previous research (Kamal & Ragy, 2012), which reported that aerobic exercise with walking and running for 12 weeks decreased the average CRP level from 2.1 mg/L to 1.2 mg/L in obese children with metabolic syndrome in Egypt at the age 8-12 years. Submaximal training with intensity running (34 min) for 8 weeks reduced the mean CRP level from 4620 pg/mL (0.00462 mg/L) to 595 pg/mL (0.000595 mg/L), and resistance training, such as pull-down, bench press, and leg press reduced the mean CRP level from 4411 pg/mL (0.004411 mg/L) to 666 pg/mL (0.000666 mg/L) in overweight and obese women with a mean age of 22 years (Mogharnasi et al., 2019).

HIIT physical exercise increases anti-inflammatory mediators, such as IL-10 and IL-1ra, which inhibit CRP synthesis, whereas CRP synthesis is caused by pro-inflammatory transduction mediators, such as IL-1, IL-6, and TNF-α (Pedersen, 2017). HIIT has also been shown to decrease IL-6, where IL-6 is a stimulator of CRP production in the liver. Therefore, when training is performed regularly, CRP level reduction in obesity can occur (Vella et al., 2017). This confirms that physical exercise can reduce inflammation by increasing antioxidant enzyme activity, such as superoxide dismutase (SOD), and by increasing anti-inflammatory mediators, such as IL-10, IL-1ra, and adiponectin, which can suppress free radicals and pro-inflammatory processes (As'ad et al., 2021).

The effect of training duration, which was 2 weeks, could also be the main factor for the insignificant changes in CRP. Two weeks of training is not optimal for reducing body weight from fat sources and could result in the insignificant decrease in CRP levels (Church et al., 2011). The significant decrease in CRP that occurred in several studies was reported to be followed by a decrease in body fat reduction (Arikawa et al., 2011). In one prior study (Church et al., 2011), specifically, the reduction in CRP caused by physical exercise was influenced by a decrease in adipose tissue. However, the limitation of this study was that there was no observation of a reduction in body fat; therefore, the exact changes in fat that occurred after training were unknown. In addition, the CRP levels of the subjects in this study were in the normal average. Meanwhile, Pearson et al. (2003) stated that when the basal CRP level is >3 mg/L, it can result in twice the risk to develop cardiovascular disease compared to CRP levels of 1 mg/L.

Conclusions

The effect of bicycling in High-Intensity Interval Training (HIIT) on the fitness component (VO2max) proved to be effective in improving physical fitness in overweight young adult women with a sedentary lifestyle. It can be caused by the improvement of the cellular metabolic function. However, HIIT has no effect on the CRP levels, it only tends to reduce in the HIIT group. Eight sessions bicycling in HIIT may have a minor effect on triggering the antiinflammation mediator which hinder the CRP. The noteworthy increase in VO2max and the trivial decreasing CRP levels illustrates that physical exercise, especially bicycling HIIT, can be a chosen activity as recommended exercise for overweight women with a sedentary lifestyle. However, further studies are needed regarding the addition of exercise sessions and other mechanisms of anti-inflammatory and pro-inflammatory mediators.

Conflicts of Interest

No potential conflicts of interest relevant to this article are reported.

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References

Alansare, A., Alford, K., Lee, S., Church, T., & Jung, H. C. (2018). The effects of high-intensity interval training vs. Moderate-intensity continuous training on heart rate variability in physically inactive adults. *International Journal of Environmental Research and Public Health*. https://doi.org/10.3390/ijerph15071508

Arikawa, A. Y., Thomas, W., Schmitz, K. H., & Kurzer, M. S. (2011). Sixteen Weeks of Exercise Reduces C-Reactive Protein Levels in Young Women. *Medicine & Science In Sports & Exercise*, 1002–1010. https://doi.org/10.1249/MSS.ObO

As'ad, M. R. F., Liben, P., & Herawati, L. (2021). Mechanism of Physical Exercise on Lowering Levels of C-Reactive Protein (CRP) in Overweight and Obese. *Folia Medica Indonesiana*, *57*(1), 82. https://doi.org/10.20473/fmi.v57i1.18258

Astorino, T., Llen, R. Y. A. N. P. A., & Oberson, D. A. W. R. (2012). Effect Of High-Intensity Interval Training On Cardiovascular Function, Vo2max, And Muscular Force. *Journal of Strength and Conditioning Research*, *26*(1), 138–145.

Bastien, M., Poirier, P., Lemieux, I., & Després, J. (2014). ScienceDirect Overview of Epidemiology and Contribution of Obesity to Cardiovascular Disease. *Progress in Cardiovascular Diseases*, *56*(4), 369–381. https://doi.org/10.1016/j.pcad.2013.10.016

Church, T. S., Earnest, C. P., Thompson, A. M., Priest, E., Rodarte, R. Q., Sanders, T., Ross, R., & Blair, S. N. (2011). Exercise Without Weight Loss Does Not Reduce C-Reactive Protein: The Inflame Study. *Med Sci Sports Exerc*, *42*(4), 708–716. https://doi.org/10.1249/MSS.0b013e3181c03a43.Exercise

Ciccarelli, M., Santulli, G., Pascale, V., Trimarco, B., & Iaccarino, G. (2013). Adrenergic receptors and metabolism : role in development of cardiovascular disease. *Frontiers in Physiology*, *4*(265), 1–6. https://doi.org/10.3389/fphys.2013.00265

García-Hermoso, A., Sánchez-López, M., Escalante, Y., Saavedra, J. M., & Martínez-Vizcaíno, V. (2016). Exercise-based interventions and C-reactive protein in overweight and obese youths: A meta-analysis of randomized controlled trials. In *Pediatric Research*. https://doi.org/10.1038/pr.2015.274

Hall, J. E., Carmo, J. M., Silva, A. A., Wang, Z., & E, H. M. (2016). Obesity-Induced Hypertension: Interaction Of Neurohumoral And Renal Mechanisms. *Circ Res*, *116*(6), 991–1006. https://doi.org/10.1161/CIRCRESAHA.116.305697.OBESITY-INDUCED

Han, T. S., & Lean, M. E. J. (2016). A clinical perspective of obesity, metabolic syndrome and cardiovascular disease. *JRSM Cardiovascular Disease*. https://doi.org/10.1177/2048004016633371

Hoeger, W. W. K., Hoeger, S. A., Fawson, A. L., & Hoeger, C. I. (2019). *Principles and labs for fitness and wellness*. 606.

Hoshino, D., Kitaoka, Y., & Hatta, H. (2016). High-intensity interval training enhances oxidative capacity and substrate availability in skeletal muscle. *The Journal of Physical Fitness and Sports Medicine*, *5*(1), 13–23. https://doi.org/10.7600/jpfsm.5.13

Kamal, N. N., & Ragy, M. M. (2012). The effects of exercise on C-reactive protein, insulin, leptin and some cardiometabolic risk factors in Egyptian children with or without metabolic syndrome. *Diabetology and Metabolic Syndrome*, *4*(1), 1–7. https://doi.org/10.1186/1758-5996-4-27

Kaur, J. (2014). Assessment and Screening of the Risk Factors in Metabolic Syndrome. *Medical Sciences*. https://doi.org/10.3390/medsci2030140

Kemenkes RI. (2018). Hasil Utama Riset Kesehatan Dasar Tahun 2018. In *Kementrian Kesehatan Republik Indonesia*. https://doi.org/1 Desember 2013

Khoury, M., Manlhiot, C., & McCrindle, B. W. (2013). Role of the waist/height ratio in the cardiometabolic risk assessment of children classified by body mass index. *Journal of the American College of Cardiology*. https://doi.org/10.1016/j.jacc.2013.01.026

Ma, E. B., Sahar, N. E., Jeong, M., & Huh, J. Y. (2019). Irisin Exerts Inhibitory Effect on Adipogenesis Through Regulation of Wnt Signaling. *Frontiers in Physiology*. https://doi.org/10.3389/fphys.2019.01085

Mamikutty, N., Thent, Z. C., Sapri, S. R., Sahruddin, N. N., Mohd Yusof, M. R., & Haji Suhaimi, F. (2014). The establishment of metabolic syndrome model by induction of fructose drinking water in male Wistar rats. *BioMed Research International*. https://doi.org/10.1155/2014/263897

Mogharnasi, M., TaheriChadorneshin, H., & Abbasi-Deloei, N. (2019). Effect of exercise training type on plasma levels of vaspin, nesfatin-1, and high-sensitivity C-reactive protein in overweight and obese women. *Obesity Medicine*, *13*(November 2018), 34–38. https://doi.org/10.1016/j.obmed.2018.12.006

Moreno-Fernández, S., Garcés-Rimón, M., Vera, G., Astier, J., Landrier, J. F., & Miguel, M. (2018). High fat/high glucose diet induces metabolic syndrome in an experimental rat model. *Nutrients*. https://doi.org/10.3390/nu10101502

Nassis, G. P., Papantakou, K., Skenderi, K., Triandafillopoulou, M., Kavouras, S. A., Yannakoulia, M., Chrousos, G. P., & Sidossis, L. S. (2005). Aerobic exercise training improves insulin sensitivity without changes in body weight, body fat, adiponectin, and inflammatory markers in overweight and obese girls. *Metabolism: Clinical and Experimental*. https://doi.org/10.1016/j.metabol.2005.05.013

Nuzzo, J. L. (2019). The Case for Retiring Flexibility as a Major Component of Physical Fitness. *Sports Medicine*. https://doi.org/10.1007/s40279-019-01248-w

Palaparthi, S. (2017). Role of Homeostasis in Human Physiology: A Review. *Journal of Medical Physiology & Therapeutics*.

Pearson, T. A., Mensah, G. A., Alexander, R. W., Anderson, J. L., Richard, O., Iii, C., Criqui, M., Fadl, Y. Y., Fortmann, S. P., Hong, Y., Myers, G. L., Rifai, N., Smith, S. C., Taubert, K., Tracy, R. P., Vinicor, F., Pearson, T. A., Mensah, G. A., Criqui, M., … Introduction, I. (2003). Markers of Inflammation and Cardiovascular Disease : Application to Clinical and Public Health Practice: A Statement for Healthcare Professionals From the Centers for Disease Control and Prevention and the American Heart Association. *Journal of the American Association*, 499–511. https://doi.org/10.1161/01.CIR.0000052939.59093.45

Pedersen, B. K. (2017). Anti-inflammatory effects of exercise: role in diabetes and cardiovascular disease. In *European Journal of Clinical Investigation*. https://doi.org/10.1111/eci.12781

Pescatello, L. S. (2014). *ACSM'S Guidelines for Exercise Testing and Prescription* (E. Lupash (ed.); 9th ed.). Lippincott Williams & Wilkins.

Rahayu, T., Aprilawati, D. W. I., Mahmud, J., Purwanto, B., & Herawati, L. (2019). Both Upper and Lower Extremity-Only Video Game-Based Exercises (Exergaming) Affect Blood Glucose Serum Levels and Heart Rates but not Oxygen Saturation in Teenagers. *Journal of Physical Education and Sport*, *19*(3), 802–807. https://doi.org/10.7752/jpes.2019.s3114

Ramos, J. S., Dalleck, L. C., Tjonna, A. E., Beetham, K. S., & Coombes, J. S. (2015). The Impact of High-Intensity Interval Training Versus Moderate-Intensity Continuous Training on Vascular Function: a Systematic Review and Meta-Analysis. In *Sports Medicine*. https://doi.org/10.1007/s40279-015-0321-z

Rask Larsen, J., Dima, L., Correll, C. U., & Manu, P. (2018). The pharmacological management of metabolic syndrome. In *Expert Review of Clinical Pharmacology*. https://doi.org/10.1080/17512433.2018.1429910

Riskesdas. (2018). Hasil Utama Riskesdas di Indonesia 2018. *Hasil Utama Riskesdas Di Indonesia 2018*, 8. https://doi.org/1 Desember 2013

Salazar-Martínez, E., Santalla, A., Orellana, J. N., Strobl, J., Burtscher, M., & Menz, V. (2018). Influence of high-intensity interval training on ventilatory efficiency in trained athletes. *Respiratory Physiology and Neurobiology*. https://doi.org/10.1016/j.resp.2018.01.016

Sanchez-garcía, L. F., Pueo, B., Penichet-tomás, A., & Jose, M. (2022). Strength profile in young male and female trail runners. *Journal of Physical Education and Sport*, *22*(1), 266–272. https://doi.org/10.7752/jpes.2022.01034

Sazali, M. F. I., Abdullah Hilmy, M., Shari, N., Herawati, L., Nordin, N. I., & Othman, Z. (2021). The effect of calorie restricted diet on anthropometric and biochemical parameters in Sprague Dawley rats. *Nutrition & Food Science*, *ahead-of-p*(ahead-of-print). https://doi.org/10.1108/nfs-01-2021-0029

Setyo, B. (2012). *Metodolgi Latihan Olahraga*.

Sloth, M., Sloth, D., Overgaard, K., & Dalgas, U. (2013). Effects of sprint interval training on VO 2max and aerobic exercise performance : A systematic review and meta-analysis. *Scandinavian Journal of Medicine and Science in Sports*, 1–12. https://doi.org/10.1111/sms.12092

Sovenko, S. (2022). Technique characteristics of 13 – 15-year-old female athletes specializing in race walking at the stage of preliminary basic preparation. *Journal of Physical Education and Sport*, *22*(1), 85–90. https://doi.org/10.7752/jpes.2022.01010

Stöggl, T. L., & Björklund, G. (2017). High intensity interval training leads to greater improvements in acute heart rate recovery and anaerobic power as high volume low intensity training. *Frontiers in Physiology*. https://doi.org/10.3389/fphys.2017.00562

Susantiningsih, T. (2015). Obesitas dan Stres Oksidatif Obesity and Oxidative Stress. *Jurnal Kesehatan Unila*.

Syamsudin, F., Wungu, C. D. K., Qurnianingsih, E., & Herawati, L. (2021). High-intensity interval training for improving maximum aerobic capacity in women with sedentary lifestyle : a systematic review and meta-analysis. *JPES*, *21*(June), 1788–1797. https://doi.org/10.7752/jpes.2021.04226

Thompson, W. R. (2019). Worldwide Survey of Fitness Trends for 2020. In *ACSM's Health and Fitness Journal*. https://doi.org/10.1249/FIT.0000000000000526

Vella, C. A., Taylor, K., & Drummer, D. (2017). High-intensity interval and moderate-intensity continuous training elicit similar enjoyment and adherence levels in overweight and obese adults. *European Journal of Sport Science*, *17*(9), 1203–1211. https://doi.org/10.1080/17461391.2017.1359679

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Health Professions
- Physical Therapy, Sports Therapy and Rehabilitation
- Sports Science

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H-INDEX

30

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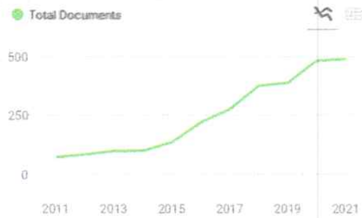

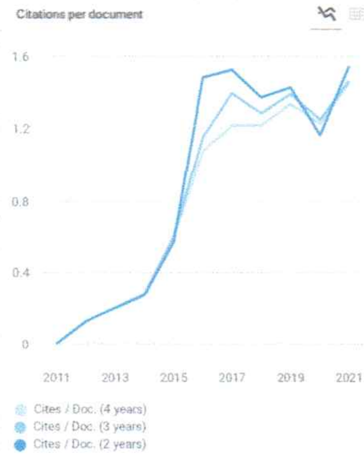

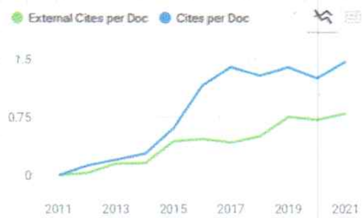

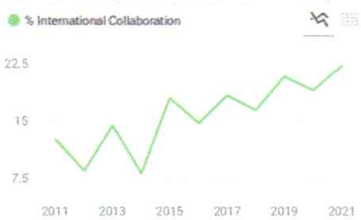

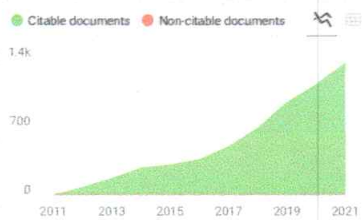

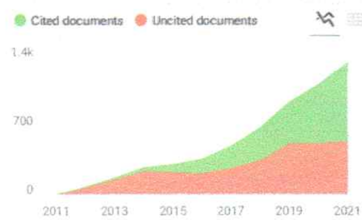

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