

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 (HR_{max}) 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–Rhyning 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≥0.05). 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/m²) also tend to have increased CRP levels compared to normal people (BMI<25 kg/m²) (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 (Riskseddas, 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

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 (Garcia-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.

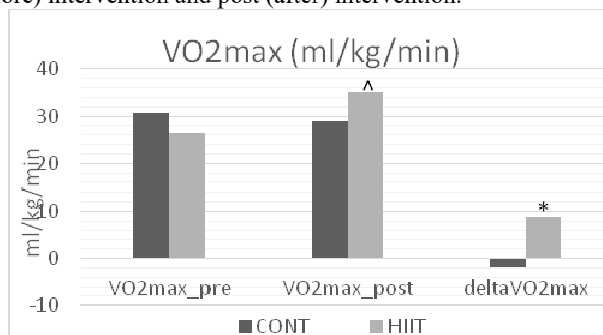


Figure 1. Mean of VO₂max in mL/kg/min

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.

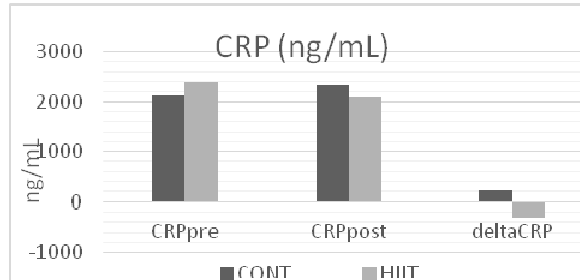


Figure 2. Mean of CRP in ng/mL

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	VO ₂ max (mL/kg/min)		ΔVO ₂ max (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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