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**Original Article**

# High-intensity interval training for improving maximum aerobic capacity in women with sedentary lifestyle: a systematic review and meta-analysis

FAJAR SYAMSUDIN[1], CITRAWATI DYAH KENCONO WUNGU[2], EMA QURNIANINGSIH[3], LILIK HERAWATI[4*]
[1,4]Master Progam of Sport Health Science, Faculty of Medicine, Universitas Airlangga, INDONESIA
[2,3]Department of Biochemistry, Faculty of Medicine, Universitas Airlangga, INDONESIA
[4]Department of Physiology, Faculty of Medicine, Universitas Airlangga, INDONESIA

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**Abstract**
*Introduction*: Sedentary lifestyle behavior increases the risk of non-communicable diseases such as diabetes mellitus, cardiovascular disease, and cancer. High-intensity interval training (HIIT) is an effective and efficient exercise to overcome this problem. It has been proven that HIIT effectively increases the maximal aerobic capacity (VO2Max) as an indicator of cardiovascular health. *Objective*: The purpose of this study was to analyze the effect of HIIT on women with sedentary lifestyle and to evaluate the difference in VO2max using the Pre and Post group design. *Methods*: Three electronic databases were searched (i.e., PubMed, ScienceDirect, and ProQuest) for original research articles. The search was performed using the following search term – 'high intensity interval training' and 'maximum aerobic capacity' and 'sedentary'. Inclusion criteria were controlled trials, healthy 18–55-year-old women, training duration >2 weeks, and VO2max assessed during pre and post training. The RevMan 5.4 software was used for analysis in fixed/random effect models. *Result*: A total of 7 studies met the inclusion criteria and were included in the meta-analysis. Meta-analysis was divided into 2 analysis groups, i.e., 6- and 12-week training. The standardized mean difference (SMD) values of 6- and 12-week-training were 1.31 (85% CI 0.42–2.21) and 1.13 (0% CI 0.70–1.57), respectively. Conclusion: HIIT with a minimum of 4 weeks of exercise training (3 times per week, 18-30 minutes per session) is an effective training protocol for increasing maximal aerobic capacity in women with a sedentary lifestyle.
**Key Words** : **HIIT, female, lifestyle, VO2max, fitness, health**

## Introduction

Sedentary style (lack of physical activity or sedentary lifestyle) increases along with the development of times (M. Lee et al., 2021; Ozemek, Lavie, & Rognmo, 2019). In addition, there are a lot of evidence showing that sedentary lifestyle increases various risks that can disrupt health conditions (I. M. Lee et al., 2012), including including can increase the risk of diabetes by 112%, increase the risk of cardiovascular diseases such as heart attacks and strokes by 147%, increase the risk of death from cardiovascular disease by 90% and increase the risk of death from various causes by 49% (Rahayu, Aprilawati, Mahmud, Purwanto, & Herawati, 2019; Wilmot et al., 2012).

The Word Health Organization (WHO) (World Health Organization, 2020) has recommended at least 150-300 minutes of moderate physical activity (40-60% HRM) or 75-150 minutes of high-intensity/ vigorous physical activity (60-85% HRM) per week to maintain and improve the stamina of healthy adults (18-64 years old). However, 31.1% of adults worldwide fail to meet these minimum physical activity guidelines, and inactivity increases with age (Hallal et al., 2012). Lack of time, low motivation, and non-compliance to established guidelines are frequently mentioned as the challenge to engage in physical activity (Hoare, Stavreski, Jennings, & Kingwell, 2017; Rech et al., 2016).

To carry out physical activity, the body needs oxygen to burn calories into energy (Guyton & Hall E, 2016). However, the oxygen capacity of each person is different (Hoeger, Hoeger, Fawson, & Hoeger, 2019). A higher oxygen capacity is an indicator of the level of cardiovascular health and enables body to perform greater physical activity (Saghiv, Sagiv, Saghiv, & Sagiv, 2020; Scott, 1998). The parameter of oxygen coverage is called the maximal aerobic capacity, in short known as VO2Max (Maximal Oxygen Volume), stated in units of $mL \cdot kg^{-1} \cdot min^{-1}$. VO2max is an indicator of cardiovascular health due to its vital role in the body (Batacan, Duncan, Dalbo, Tucker, & Fenning, 2017). VO2max can be increased by routine and programmed exercise (Arboleda-Serna, Feito, Patiño-Villada, Vargas-Romero, & Arango-Vélez, 2019; Astorino et al., 2017).

HIIT is one of the exercises recommended for someone who doesn't have much leisure time. HIIT is less time-consuming compared to over low or moderate intensity or continuous training, making it more preferable to provide similar or greater health benefits than the recommended physical activity (Norton, Norton, & Sadgrove, 2010; Ramos, Dalleck, Tjonna, Beetham, & Coombes, 2015). HIIT can overcome the challenge of


Corresponding Author: LILIK HERAWATI, E-mail: lilik_heraw@fk.unair.ac.id

lack of time to perform physical (Reichert, Barros, Domingues, & Hallal, 2007; Syamsudin, Herawati, Qurnianingsih, & Wungu, 2021), making HIIT the third most popular sport in the world (Thompson, 2018). It was also reported that HIIT is good to improve fitness, cardiovascular function, insulin sensitivity, and reduce atherosclerosis (Kong et al., 2016; Lanzi et al., 2015).

As such, HIIT is in great demand and beneficial method for improving fitness and cardiovascular health levels (Batacan et al., 2017). However, the current systematic review of HIIT remains limited to subjects that are mixed between men and women (Kriel, Askew, & Solomon, 2019; Viana et al., 2019). It has not focused on female subjects although the prevalence of obesity is more dominant in women (World Health Organization, 2016) and problems associated with ovulatory dysfunction are mostly found in obese females(Broughton & Moley, 2017). In addition, there is no systematic review that is specifically focused on sedentary lifestyle or physical inactivity. Therefore, this systematic review was aimed to analyze the effect of HIIT on maximum aerobic capacity in female subjects whose sedentary lifestyle and physical inactivity in the normal, overweight, and obese categories based on published studies.

**Materials & methods**

This systematic review article followed the guidelines for Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Moher et al., 2016), and was registered in the International Prospective Register of Systematic Review (PROSPERO) (Chien, Khan, & Siassakos, 2012) (CRD42020218218).

*Search Strategy.* Electronic databases were searched in PubMed, Science Direct, and ProQuest. The keywords used in the search process were completed with MeSH Terms, Titles / Abstracts, and asterisks (*) for words that are likely to have various types of subsequent words. “High Intensity Interval Training OR High Intensity Interval Exercise OR High Intensity Intermittent Exercise OR Interval Training OR Interval Exercise OR HIIT OR Sprint Interval Training OR Sprint Training” **AND** “Sedentary OR Sedentary* OR Sedentary Lifestyle OR Sedentary Behaviour* OR Inactive OR Inactive* OR Physical Inactivity” **AND** “VO2Max OR VO2 Max OR VO2Max OR Maximum Oxygen Volume OR Maximum Oxygen Capacity OR Maximal Oxygen Uptake” were used as keywords. In addition to the obtained articles, several articles beside the unpublished database were used.

*Inclusion and Exclusion criteria : Participants, Intervensions, Comparations and Outcomes*. Studies on female subjects whose a sedentary lifestyle between the ages of 18-65 years, subjects were given high-intensity training with intervals, training included weight-bearing or non-weight bearing. Studies were not limited to treatment comparisons, may be compared to any exercise treatment such as MICT (Moderate Intensity Continuous Training), circuit training, resistance training or control, and each study should have a result on VO2Max (Maximum Oxygen Volume).

*Data Extraction.* The characteristics of the study must meet data on gender, age, VO2max, filtering sedentary questionnaires, tools used in the intervention, bouts/active and rest/passive phases of training, and data in each group must have Pre and Post Test data. For any incomplete data, the author of the article was contacted to provide complete data or clarification of the data needed. However, if there was no response, it was included or excluded with several conditions.

*Assessment of Bias.* Two investigators independently performed the electronic search and retrieved the articles that matched with our searched terms. Any disagreement was settled by discussion and consensus with all the authors. Final decision was merely based on the agreements of all authors.

*Study Quality Assessment*. The quality of each study was assessed using the Jadad Score. Jadad Score consists of three items related to the description of randomization (0–2 points), blinding (0–2 points), and drop-out (0–1 points) with a total of five scores. Higher scores indicate better quality. High-quality trials were defined as trials that score more than 2. A low-quality trial was defined as trials that score 2 or less.

*Data Analysis.* Analysis was conducted using Review Manager 5.3 software (The Cochrane Collaboration, UK). Hardy Weinberg Equilibrium was examined by Chi Square test when the raw information was not provided. The standardized mean difference (SMD) data were evaluated in all obtained studies. Heterogeneity assumption was assessed with Cochrane Q statistic and I2 statistic. The pool estimated ORs was calculated with either fixed or random effects model assumptions. If Q test showed significant result ($p < 0.05$), a random effects model was used. Otherwise, if Q test showed insignificant result ($p > 0.05$), a fixed effect model was used. 95% confidence interval (CI) of pool estimated SMD was also calculated. Inverted funnel plots were used to find any publication bias.

**Result**

The search strategy from electronic and non-electronic database resulted in 2321 and 4 articles, respectively. After checking for duplication using Mendeley, the number of articles decreased by 34, leading to exclusion of 2264 articles through the screening process by reading titles and abstracts. The remaining 24 articles were selected in full text; however, after understanding them in full text, 16 articles were published for the following reasons: (1) Five data were mixed with men; (2) Two single articles were bout; (3) Six articles did not provide VO2Max data; (4) One article was not sedentary; (5) One article involved youth subjects; (6) One HIIT

article was conducted simultaneously with Resistance Training; and (7) One subject article had disease. In the end, 7 articles provided sufficient data was analyzed in a systematic review. 6 articles were then used for meta-analysis and divided into 2 categories such as 6-week and 12-week meta-analysis.

*Study Quality.* Results of the quality of all studies were analyzed (Astorino et al., 2013; Bhati, Bansal, & Moiz, 2017; Clark, Rosa, DeRevere, & Astorino, 2019; Metcalfe, Tardif, Thompson, & Vollaard, 2016; Nie et al., 2018; Trilk, Singhal, Bigelman, & Cureton, 2011) using the jadad score. A total of six studies (Astorino et al., 2013; Bhati et al., 2017; Clark et al., 2019; Nie et al., 2018; Trilk et al., 2011) were high quality, and only one study (Metcalfe et al., 2016) was low quality.

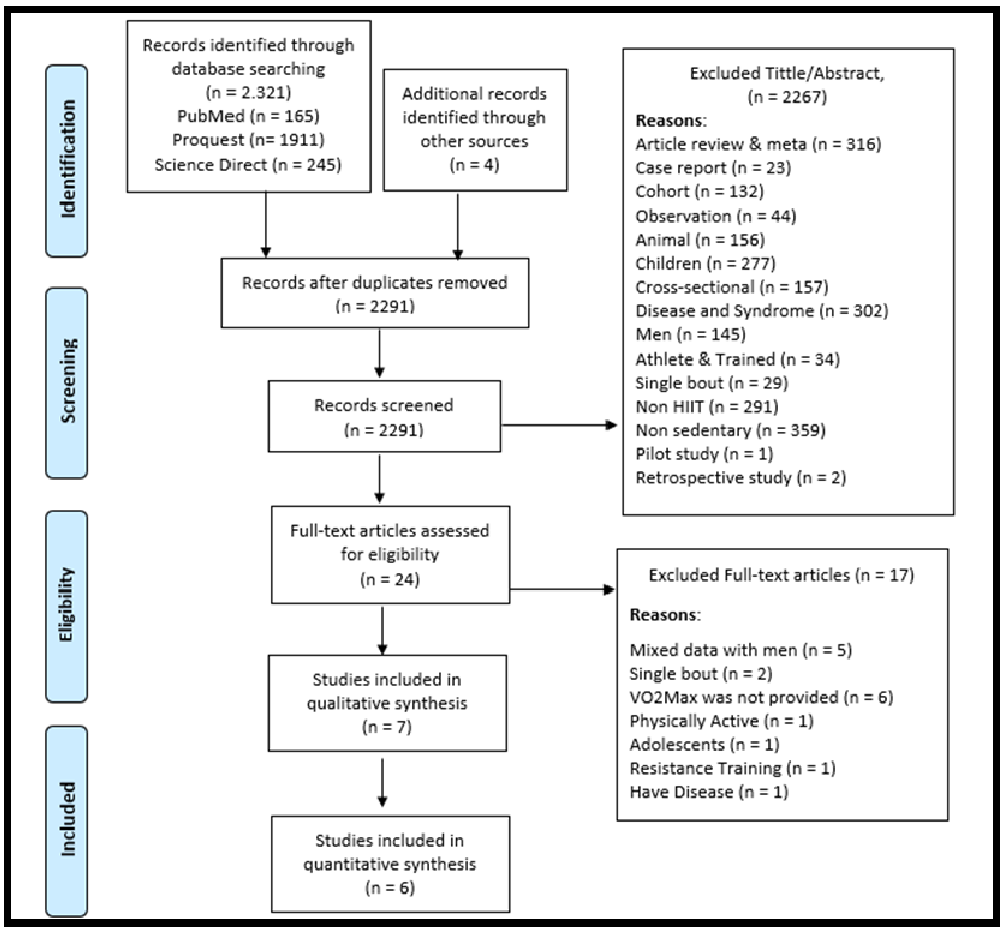


**Fig. 1** Prisma Flow diagram ilustrating the study selection process.

*Characteristics of Participant.* The characteristics of participants were summarized in **Table 2**. All 130 participants were included in the systematic review. Study (Astorino et al., 2013; Bhati et al., 2017; Nie et al., 2018; Zhang et al., 2015) used subjects with an average age of 17-30 years, while study (Clark et al., 2019; Metcalfe et al., 2016; Trilk et al., 2011) used subjects with an average age of 30-45 years. The number of participants in each study was different, ranging from 8-18 people in each group. Studies by (Bhati et al., 2017; Metcalfe et al., 2016) involved normal BMI subjects, two studies by (Astorino et al., 2013; Nie et al., 2018) involved the overweight category, while a study by Trilk et al. (2011) involved subjects with class 1 obesity and a study by Clark et al. (2019) involved subjects with class 2 obesity.

*Characteristics of Intervention.* High-intensity interval training (HIIT) describes physical exercise that is characterized by brief, intermittent bursts of vigorous activity, interspersed by periods of rest or low-intensity exercise (Gibala, Little, Macdonald, & Hawley, 2012; MacInnis & Gibala, 2017). The HIIT programs were summarized in **Table 1**. Five studies (Astorino et al., 2013; Clark et al., 2019; Metcalfe et al., 2016; Nie et al., 2018; Trilk et al., 2011) used a cycle ergometer as an intervention tool, while two studies (Bhati et al., 2017; Zhang et al., 2015) used treadmills.

Duration of training varied, intervention in three studies (Astorino et al., 2013; Nie et al., 2018; Zhang et al., 2015) were given over twelve weeks, four studies (Bhati et al., 2017; Clark et al., 2019; Metcalfe et al., 2016) were given for six weeks, one study (Trilk et al., 2011) was given for four weeks. For one-week intervention, nearly all studies (Astorino et al., 2013; Bhati et al., 2017; Clark et al., 2019; Metcalfe et al., 2016;

Trilk et al., 2011) were performed 3 times, and one study Nie et al., (2018) was performed 3-4 times progressively.

Volume of training provided varied, studies (Metcalfe et al., 2016; Zhang et al., 2015) took no more than 15 minutes, a fixed volume of training from the beginning of the meeting to the end of the meeting was carried out in the study by (2 groups) Bhati et al., (2017) and study by Clark et al., (2019), with volume of 22 minutes, 43 minutes and 25 minutes. In addition, study by (Astorino et al., 2013; Trilk et al., 2011) had a progressive volume, while a study by Nie et al. (2018) used energy expenditure benchmarks.

Intensity of all studies was high, but had different measuring instruments, four studies (Astorino et al., 2013; Bhati et al., 2017; Clark et al., 2019; Zhang et al., 2015) used 70-100% HRmax, one study (Nie et al., 2018) used 90 - 95% VO2max, and two studies (Metcalfe et al., 2016; Trilk et al., 2011) asked subjects to do maximum sprint / all-out.

**Table 1. Quality Assessment of Articles**

| No | Study | Randomization | Blinding | Drop-Out | Total of | Concealment |
|---|---|---|---|---|---|---|
| 1. | Metcalfe et al., (2016) | 0 | 1 | 1 | 2 | Low quality |
| 2. | Bhati et al., (2017) | 2 | 0 | 1 | 3 | High quality |
| 3. | Trilk et al., (2011) | 2 | 0 | 1 | 3 | High quality |
| 4. | Clark et al., (2019) | 1 | 1 | 1 | 3 | High quality |
| 5. | Astorino et al., (2013) | 1 | 1 | 1 | 3 | High quality |
| 6. | Nie et al., (2018) | 2 | 1 | 1 | 4 | High quality |
| 7. | Zhang et al., (2015) | 2 | 0 | 1 | 3 | High quality |

Note: Jadad Score consists of three items related to the description of randomization (0–2 points), blinding (0–2 points), and drop-out (0–1 points) with a total of five scores. Higher scores indicated better quality. High-quality trials were defined as trials that scored more than 2. A low-quality trial was defined as trials that scored 2 or less.

*Sedentary Lifestyle.* All subjects were categorized as healthy, four studies (Bhati et al., 2017; Clark et al., 2019; Metcalfe et al., 2016; Trilk et al., 2011) used the PAR-Q (Physical Activity Readiness Questionnaire) to assess the health quality of subjects, while four other studies did not use the PAR-Q questionnaire but provided information that subjects were healthy and did not have a disease that could harm the subject itself. To determine sedentary lifestyle subjects, two studies by Astorino and Nie (Astorino et al., 2013; Nie et al., 2018) used PYTPAQ (Past Year Total Physical Activity Questionnaire), a study by Metcalfe et al. (2016) used IPAQ (International Physical Activity Quitionnaire), while another study did not use a questionnaire but confirmed that the subjects had sedentary lifestyle, with different criteria in each study. More details can be seen in **Table 2.**

**Table 2. Characteristics of study population and studies**

| No | Author | Country | Sedentary Questionnaire | Age & BMI | Group Size | Interventions | Pre VO2Max ($mL \cdot kg^{-1} \cdot min^{-1}$) | Post VO2Max ($mL \cdot kg^{-1} \cdot min^{-1}$) | P-value of Pre Post Test |
|---|---|---|---|---|---|---|---|---|---|
| 1. | Metcalfe et al., (2016) | United Kingdom | IPAQ, PAR-Q Body mass stable and no conscious change in diet or physical activity patterns over the preceding 6 months | A : 36 ± 9<br>B : 24.1 ± 3.5 (overweight) | Size (35)<br>Male (17)<br>**Female (18)** | T : Cycle Ergometer<br>D : 6 weeks, 3x per week<br>V : 10 min per training<br>I : 10 – 40 s sprint, 3-4.50 min passive, ariation and progression | 31.7 ± 4.6 | 34.7±5.2 | < 0.001 |
| 2. | Bhati et al., (2017) | India | PAR-Q Not engaging in any leisure time physical activity or | A : 22.0 ± 0.3<br>B : 21.3 ± 0.3 (normal) | Size 28<br>**LVHIIT (17)**<br>HVHIIT (15) | T : Treadmill<br>D : 6 weeks, 3 x per week<br>V : 22 min **(LVHIIT)**<br>I : 4 min active – 3 min recovery, | 20.4 ± 0.6 | 23.1 ± 0.6 | < 0.001 |

| No | Author | Country | Sedentary Questionnaire | Age & BMI | Group Size | Interventions | Pre VO2Max ($mL_i \cdot kg^{-1} \cdot min^{-1}$) | Post VO2Max ($mL_i \cdot kg^{-1} \cdot min^{-1}$) | P-value of Pre Post Test |
|---|---|---|---|---|---|---|---|---|---|
| | | | there was only one instance of low-intensity exercise or sports activity for less than 20 min in a week No participation in any aerobic or resistance training in the last 6 months | | | active : 85–95% HRmax, Passive : 70% HRmax | | | |
| | | | | A : 22.0 ± 0.3 B : 21.3 ± 0.3 (normal) | Size 28 LVHIIT (17) **HVHIIT (15)** | T : Treadmill D : 6 weeks, 3 x per week V : 43 min **(HVHIIT)** I : 4 min active – 3 min recovery, active : 85–95% HRM, passive : 70% HRM | 20.9 ± 0.6 | 22.6 ± 0.8 | < 0.04 |
| 3. | Trilk et al., (2011) | USA | Sedentary Exercise < 1 day per week | A : 35.7 ± 6.3 B : 30.1 ± 6.8 (class 1 obesity) | Size 28 **SIT (14)** Control (14) | T : Cycle Ergometer D : 4 weeks, 3 x per week V : 18 – 31.30 menit I : 30 s active, 4 min passive, 4-7 sets, progressive, Active : All-out (sprint), Passive : Active recovery | 21.6 ± 1.1 | 24.5 ± 1.1 | < 0.05 |
| 4. | Clark et al., (2019) | USA | PAR-Q Sedentary < 2 hour of moderate-to-vigorous activity per week in the previous 12 months | A : 39.1 ± 4.3 B : 37.5 ± 10.5 (class 2 obesity) | Size 17 **HIIT Tradit (9)** HIIT Period (8) | T : Cycle Ergometer D : 6 weeks, 3x per week V : 25 min I : WU – 5 min, Active 60 s – passive 60 s, 10 sets, active : 80–95% HRM, passive : - | 21.5 ± 3.2 | 22.5 ± 3.2 | < 0.44 |
| | | | | A : 39.1 ± 4.3 B : 37.5 ± 10.5 (class 2 obesity) | Size 17 HIIT Tradit (9) **HIIT Period (8)** | T : Cycle Ergometer D: 6 weeks, 3x per week V : 25 min I : WU – 5 min, variation active and passive, variation sets, active : 80–95% HRM, passive : - | 17.3 ± 2.4 | 18.0 ± 2.2 | < 0.49 |
| 5. | Astorino et al., | USA | PYT-PAQ | A : 23.1 ± 5.6 | Size 27 **HI.HIIIT** | T : Cycle Ergometer | 29.4 ± 5.9 | 6 week 34.8 ± | < 0.05 |

| No | Author | Country | Sedentary Questionnaire | Age & BMI | Group Size | Interventions | Pre VO2Max ($mL_i \cdot kg^{-1} \cdot min^{-1}$) | Post VO2Max ($mL_i \cdot kg^{-1} \cdot min^{-1}$) | P-value of Pre Post Test |
|---|---|---|---|---|---|---|---|---|---|
| | (2013) | | | B : 25.3 ± 4.3 (overweight) | **(10)** LOHIIT (10) Control (7) | D : 12 weeks, 3x per week<br>V : 12-23 min<br>I : 6-10 s bouts, 75 s recovery, 6-10 sets, active : 85–100 % HRM, passive: - | | 5.7<br>12 weeks<br>35.8 ± 5.7 | |
| | | | | A : 24.7 ± 7.6<br>B : 22.5 ± 4.5 (overweight) | Size 27<br>HI.HIIT (10)<br>**LO.HIIT (10)**<br>Control (7) | T : Cycle Ergometer<br>D : 12 weeks, 3x per week<br>V : 12-23 min<br>I : 6-10 s bouts, 75 s recovery, 6-10 sets, active : 75-95 % HRM, passive : - | 29.4 ± 5.9 | 6 weeks<br>34.1 ± 4.9<br>12 weeks<br>36.4 ± 4.4 | < 0.05 |
| 6. | Nie et al., (2018) | China | PYT-PAQ<br>Body fat percentage ≥35%<br>Body weight remained constant (±2 kg) during the past 3 months<br>No regular physical activities or exercise training | A : 21.0 ± 1.1<br>B : 26.3 ± 3.6 (overweight) | Size 48<br>**HIIT (17)**<br>MICT (15)<br>Control (16) | T : Cycle Ergometer<br>D : 12 weeks, 3-4x per week, progressive<br>V : The duration of training was based on the use of energy, which was 200-300kJ<br>I : 4 min bouts 90% VO2max, 3 min passive | 30.2 ± 4.4 | 34.3 ± 4.6 | < 0.05 |
| 7 | Zhang et al., (2015) | China | No regular physical training<br>Body weight remained constant (±2 kg) during the past 3 month | A : 21.0 ± 1.0<br>B : 25.8 ± 2.7 (overweight) | Size 35<br>**HIIT (12)**<br>MICT (12)<br>Control (11) | T : Treadmill<br>D : 12 weeks, 4x per week<br>V : 15 min<br>I : 4 min 85-95% HRM, 3 min 50-60% HRM, and 7 min active rest | 33.1 ± 3.0 | 37.7 ± 3.0 | < 0.05 |

**Questionnaire**: PAR-Q, Physical Activity Readiness Questionnaire; IPAQ, International Physical Activity Questionnaire; PYT-PAQ, Past Year Total Physical Activity Questionnaire**. Age & BMI** : A, Age; B, BMI. **Interventions**: T, Treatment; D, Duration; V, Volume; I, Intensity. **Group** : HIIT, High Intensity Interval Training; LVHIIT, Low Volume High Intensity Interval Training; HVHIIT, High Volume High Intensity Interval Training; SIT, Sprint Interval Training; HI.HIIT, High Intensity-High Intensity Interval Training; LO.HIIT, Lower Intensity-High Intensity Interval Training.

Seven research groups with 87 subjects were included to prove the effects of HIIT for six weeks. Because heterogeneity was found in the statistical analysis, a sensitivity analysis was performed to evaluate the

source of the heterogeneity. It was found that the heterogeneity between the studies was mainly due to Bhati's et al., (2017) study with the 2 research groups of HV and LV, because no significant heterogeneity was found after this study was excluded. The heterogeneity between studies for all models (I2) was 85% and the P value for heterogeneity was 0.004. Random -Effect Model was applied. The results of the analysis showed a significant increase in VO2max with a p value of 0.04 (<0.05) and an SMD value of 1.31 with a percentage of 85% with a minimum and maximum CI limit of 0.42 and 2.21, respectively. Therefore, it was concluded that 6-week training led to 1.31 times increase in VO2max from pre-test to post test.

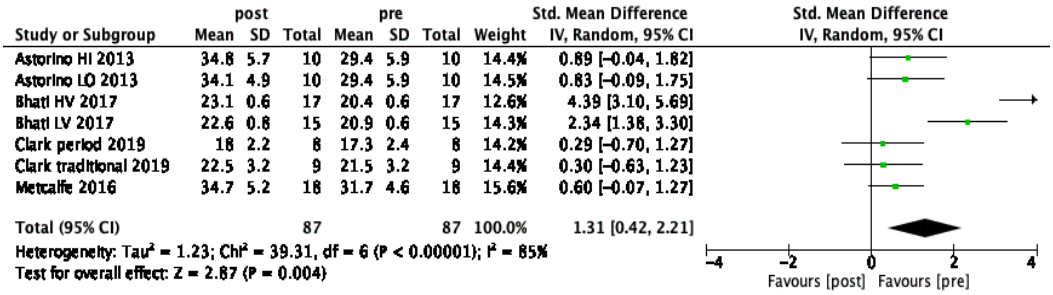


**Fig. 2. Forest plot of 6-week training**

Four research groups consisting of 49 subjects were included to prove effect of HIIT for twelve weeks. In this meta-analysis, there was no significant change in SMD by excluding any study, indicating that there was no single study that affected the statistical significance in whole results.

Results of analysis showed a significant increase of VO2max with p-value 0.00001 (p<0.05), SMD value of 1.45, percentage of 81%, minimum and maximum CI limit of 0.80 and 2.11, respectively. Therefore, it was concluded that 12-week training led to increased VO2max from pre-test to post-test.

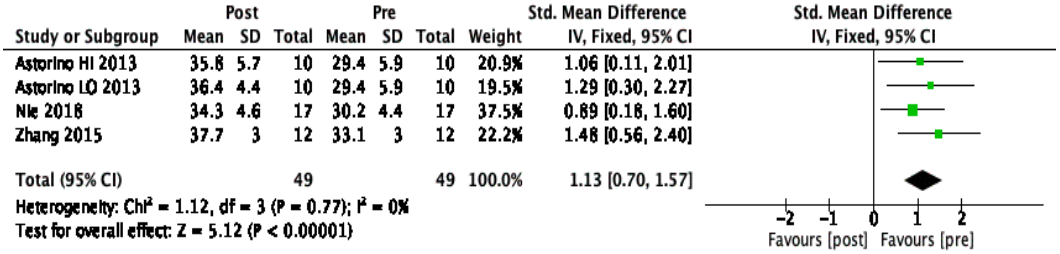


**Fig. 3. Forest plot of 12-week training**

The funnel plot image showed an asymmetrical distribution of the study, indicating an imbalance in left and right side of center line boundary. This might be due to the heterogeneity of the study by Bhati. Therefore, it was concluded that publication bias affected the relationship between 6-week HIIT training and VO2max.

The funnel plot image showed a symmetrical distribution of study, indicating a balanced distribution to the left and right side of the center line boundary. Therefore, it was concluded that publication bias did not affect the relationship between 12-week HIIT training and VO2max.

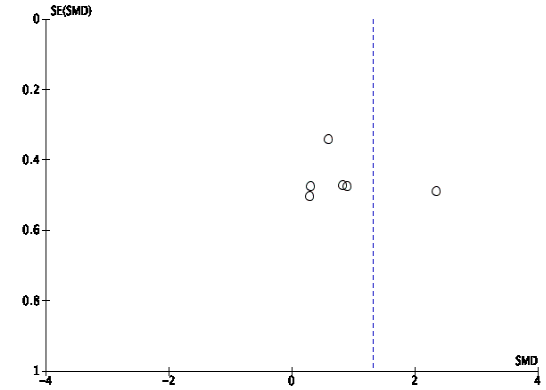


**Fig. 4. Funnel Plot of 6-week training**

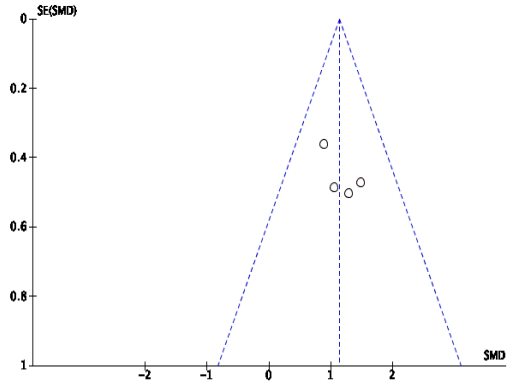


**Fig. 5. Funnel Plot of 12-week training**

**Discussion**

The aim of this systematic review and meta-analysis was to review some references analyzing HIIT in sedentary women and determine its potential effects on cardiovascular health. In addition, this meta-analysis aimed to identify the HIIT protocol in relation to the comparison of the pre and post test results of VO2max. Seven studies with 10 training groups were evaluated for evidence showing that HIIT can increase VO2max in sedentary women. The main finding from the meta-analysis was that HIIT training significantly increased VO2max.

In the Pre Test data, two studies by (Metcalfe et al., 2016; Zhang et al., 2015) showed average VO2max levels, 5 studies (Amaro-Gahete et al., 2019; Astorino et al., 2013; Clark et al., 2019; Nie et al., 2018; Trilk et al., 2011) showed that the subjects had fair VO2max levels, while study by Bhati (2) and Clark showed poor VO2max levels in 3 research groups. After HIIT training, increased VO2max were found in all studies, except three studies by (Amaro-Gahete et al., 2019; Astorino et al., 2013; Nie et al., 2018) which managed to increase the VO2max to an average level from the previously fair level. However, this proved that people with a sedentary lifestyle have a low level of cardiovascular fitness, highlighting the important role of HIIT to improve cardiovascular fitness in people with sedentary lifestyle.

The study by Bhati et al. (2017) explained that there was no significant difference in post test results of VO2max between HIIT volume training with a duration of 43 minutes compared to that of 22 minutes which was carried out with the same number of meetings and durations. This result indicated that training in the same number of sessions but different training volumes led to similar or slightly different results.

A study by Metcalfe et al. (2016) proved that time-saving was indeed one advantage of HIIT. It was shown this study that training in one meeting which lasted only 10 minutes and a total of only 30 minutes for one week provided significant results between pre and post.

Studies by (Clark et al., 2019; Trilk et al., 2011) which involved subjects with class 1 and class 2 obesity showed that exercise is very important for overweight people because their fitness level is very low. The fitness level was determined based on Hoeger et al. (2019) criteria suggesting that fair level is for women aged 30-39 years with VO2max <20 – 27,9 $mL \cdot kg^{-1} \cdot min^{-1}$ and poor level if they have VO2max <19. $mL \cdot kg^{-1} \cdot min^{-1}$. In the study by Trilk et al. (2011) the VO2max level was only 21.6 ± 1.1 - 24.5 ± 1.1 $mL \cdot kg^{-1} \cdot min^{-1}$, while in the study by Clark et al. (2019) the VO2max level was only 17.3 ± 2.4 - 18.0 ± 2.2 $mL \cdot kg^{-1} \cdot min^{-1}$. Clark et al. (2019) also compared HIIT with the same exercise program from the first meeting to the last, with HIIT training programs that varied in active volume (sprint), passive (recovery) and intensity. The results showed that a variety of exercise programs led to better results than a monotonous training program.

It was shown in a study by Astorino et al. (2013) which compared HI.HIIT and LO.HIIT that a longer meeting in HIIT training led to better VO2max results. It was shown that in week 3, 6, 9, and 12, there were increased VO2max levels.

The forest plot of 6-week training showed that the intervention led to 1.31 times increase of VO2max from pre-test to post test, with a minimum limit of increase of 0.42 and a maximum limit of increase of 2.21. Furthermore, in forest plot **Fig. 3.** the 12-week training showed that the intervention led to 1.13 times increase of VO2max with a minimum limit of increase of 0.70 and a maximum limit of increase of 1.57. Both forest plots **Fig. 2.** and **Fig. 3.** used a confidence level of 95% and an error rate of 5%.

Publication bias is a problem in meta-analysis because it only takes published research (without unpublished research) and only combines research results without critical identification, leading to an overly optimistic meta-analysis model. Funnel plot is a technique used for identification of publication bias in meta-analysis. The following is a funnel plot on the effect of HIIT on VO2max in women with sedentary lifestyle, which was divided based on the duration of treatment.

Funnel plot **Fig. 4.** shows asymmetrical distribution of the research, because there was a study which showed a great result effect causing no compatibility between the average data and the maximum data from the effect data of other studies. Therefore, it was suggested that the research group of funnel plot had a high probability of bias. Furthermore, funnel plot **Fig. 5.** shows the symmetrical distribution of research because there was no great difference of results effect from one another. Therefore, it was suggested that the research group of funnel plot had a small possibility of bias.

**Conclusion**

The findings of this systematic review indicated that HIIT is an effective training protocol to increase the maximal aerobic capacity in female subjects with a sedentary lifestyle. A minimum of 4 weeks of exercise with a frequency of 3 times per week, a training duration of 18-30 minutes per session, and various types of HIIT exercises such as circuit training, treadmill, and cycle ergometer must be considered to achieve an increased maximal aerobic capacity. However, it should be noted that in order to achieve the expected results, this exercise must achieve 85-95% HRM.

**Conflict Of Interest**

No potential conflict of interest relevant to this article was reported.

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