International Journal of Scientific Advances
ISSN: 2708-7972
Volume: 4 | Issue: 6 | Nov – Dec 2023 Available Online: www.ijscia.com
DOI: 10.51542/ijscia.v4i6.21

Heart Rate Response and Heart Rate Recovery After Harvard Step Test Between Young High Intensity Aerobic Athletes Smokers and Non-Smokers

I Wayan Prasetya Wisuda*, I Kadek Susila Surya Darma, and AA Ayu Dwi Adelia Yasmin

Department of Cardiology and Vascular Medicine, Faculty of Medicine
Udayana University/ Prof. dr. I.G.N.G. Ngoerah Hospital, Denpasar, Bali, Indonesia

E-mail: prasetyawisuda2006@gmail.com; kadeksusila138@gmail.com; adeliajasmine@gmail.com

*Corresponding author details: I Wayan Prasetya Wisuda; prasetyawisuda2006@gmail.com

ABSTRACT

Background: Smoking has an influence on physiological responses and exercise performance. Exercise training results in a slow resting heart rate through changes in cardiac autonomic balance in addition to intrinsic remodeling of the sinoatrial node. Compared with athletes in static sports, heart rate is slower in athletes involved in dynamic sports. However, not many studies have examined how smoking affects the heart rate response and heart rate recovery in high-intensity aerobic athletes. ***Methods:*** This cross-sectional observational study. Data on age, gender, body mass index, smoker or non-smoker status, resting heart rate, and blood pressure before the test were collected. Maximum heart rate, heart rate 1 minute after maximum, heart rate recovery, and blood pressure after the test were measured. Data were analyzed using the SPSS version 24 program: unpaired t-test, Mann-Whitney test, ANCOVA. ***Results:*** A total of 50 samples were involved in the study, divided into 25 smoking athletes and 25 non-smoking athletes. The mean resting heart rate in smoking athletes was significantly higher (75 vs 66, p<0.001). The mean maximum heart rate was higher in smoking athletes but not statistically significant (149.5 vs 147.6, p=0.635). The mean 1-minute heart rate after the test was found to be significantly higher in smoking athletes (123 vs 112, p=0.018). The mean heart rate recovery was significantly lower in the smoking athletes (26.3 vs 35.2, p=0.002). Covariate analysis of age, gender, and body mass index did not have a simultaneous effect on resting heart rate, maximum heart rate, 1-minute heart rate after the test, and heart rate recovery (p>0.05). ***Conclusion:*** Resting heart rate and 1-minute heart rate after the Harvard Step Test were higher in young high-intensity aerobic athletes who were smokers. Heart rate recovery was lower in young high-intensity aerobic athletes who were smokers.

Keywords: athletes; smokers; Harvard Step Test; resting heart rate; heart rate response; heart rate recovery

INTRODUCTION

Smoking-related diseases are one of the most frequent causes of premature death worldwide. According to the 2013 ESC, smoking triggers 28% of cardiovascular deaths in men and 13% in women, aged between 35 and 69 years. Long-term smoking has multiple effects on the cardiovascular system, respiration, and circulation, increasing the incidence of coronary heart disease and myocardial infarction [1]. Globally, in 2015 more than 1.1 million people smoked tobacco and this number is still increasing. The high rate of health complications associated with smoking is also increasing, with more than one in ten cases of cardiovascular death (54% of all deaths) attributable to tobacco smoking [2].

The number of adult smokers in Indonesia has increased in the last ten years. The results of the 2021 Global Adult Tobacco Survey (GATS) launched by the Ministry of Health (Kemenkes), there was an increase in the number of adult smokers by 8.8 million people, from 60.3 million in 2011 to 69.1 million smokers in 2021. Although the prevalence of smoking in Indonesia has decreased from 1.8% to 1.6%.

Smoking is one of the most important behavioral factors of cardiovascular disease [3]. The risk of having a heart attack is twice as high in heavy smokers or people with a cigarette consumption of 20 cigarettes a day [4].

One factor that is often associated with coronary heart disease is smoking. WHO states that smoking causes about 6 million deaths each year. This is predicted to increase to 8 million deaths annually by 2030 [5]. More than 6 million people die as active smokers and about 890,000 others die from exposure to cigarette smoke or known as passive smoking. As many as 80% of the 1.1 billion smokers worldwide are from low- and middle-income countries [6]. Previous research among professional athletes in Iran found that 24.6% of athletes had smoking experience and 9% were still smoking. While smoking among Olympic athletes from Finland reported a case of 11.4% [7].

In the cardiovascular system, smoking induces changes that can be detected even before cardiovascular disease is diagnosed. These early adverse changes include impairment of cardiovascular and endothelial function, increased blood pressure, and autonomic nervous system function as reflected by decreased heart rate variability. Smoking is recognized as a major risk factor that causes autonomic imbalance through sympathoexcitatory effects. Physiologically, nicotine in cigarettes induces catecholamine release from adrenergic nerve endings when inhaled. In addition, smoking produces smoke from organic particulates in cigarettes which also causes autonomic imbalance [8].

There is a strong relationship between heart rate and cardiovascular health. Heart rate is a very important index of myocardial work, non-invasive and easy to measure. The heart rate response during physical exercise and the decrease in heart rate after physical exercise are also excellent markers of cardiac autonomic control. There are studies that suggest that the finding of a blunted increase in heart rate during progressive physical exercise (chronotropic incompetence) and a weakened decrease in heart rate during the recovery phase of physical exercise are important markers of underlying autonomic dysfunction associated with increased cardiovascular morbidity and mortality. High resting heart rate and abnormal heart rate responses during or after physical exercise may precede the manifestation of cardiovascular disease and may contribute to the early identification of individuals at high risk [9].

Smoking has an influence on physiological responses and exercise performance. Smokers have higher resting heart rate, maximal heart rate, and heart rate during exercise compared to non-smokers. Overall, the heart rate response to tobacco smoking may be implicated in the association between smoking and cardiovascular disease [10]. However, although the effects of smoking on heart rate appear to be age-dependent, little is known about how smoking affects heart rate in young adults.

Physical exercise is the most prominent condition for obtaining a normal cardiovascular system. Physical exercise is associated with various cardiovascular adaptations, such as an increase in heart rate, maximal oxygen uptake, and blood pressure in response to an increase in oxygen demand. Long-term cardiac adaptations to physical exercise include a decrease in resting heart rate and an increase in heart rate recovery. Heart rate recovery is a predictable index of physical fitness and cardiovascular risk [1].

High-intensity aerobic exercise significantly reduced resting heart rate and induced positive changes in resting autonomic modulation with parasympathetic activation and sympathetic withdrawal in healthy male smokers. High-intensity aerobic exercise resulted in a significant increase in high-frequency band power and a decrease in the ratio of low-frequency band power/high-frequency band power on spectral analysis, whereas moderate-intensity exercise did not produce significant results. Thus, high-intensity aerobic exercise compared to moderate-intensity aerobic exercise is needed in smokers to improve parasympathetic activation [9].

In a study by Choun-Sub Kim et al, using a sample of smokers with high-intensity aerobic exercise treatment for 8 weeks on a treadmill, there was a significant increase in VO2max. [9]. In addition, parasympathetic activity indices such as rMSSD, pNN50, SD1, and SD1/SD2 ratio, were significantly improved in the group with high-intensity aerobic exercise. These findings suggest that improvements in cardiorespiratory fitness through high-intensity aerobic exercise may contribute to the development of autonomic regulation, regardless of the training mode.

There are easy and non-invasive ways to measure indices of myocardial work and its impact on cardiovascular health [1]. One component of measuring an individual's physical fitness is to measure the individual's cardiorespiratory fitness using an exercise test. An exercise test that is easy to perform, does not require complicated equipment and does not require a large space is the Harvard Step Test. This test uses a 20-inch bench. The subject undergoes the exercise test going up and down the bench for five minutes at a rate of 30 times per minute or until exhaustion [11].

Exercise training results in a slower resting heart rate through changes in the autonomic balance of the heart in addition to intrinsic remodeling within the sinoatrial node itself. Compared to athletes who engage in static sports such as weightlifting, heart rate is generally slower in athletes who engage in dynamic sports such as running or cycling. However, not many studies have examined how smoking affects heart rate response and heart rate recovery in high-intensity aerobic athletes, where heart rate recovery is defined as the difference between peak heart rate and 1-minute heart rate during recovery time after physical exercise. Measurement of heart rate recovery is widely used in clinical practice as a simple, inexpensive, and valid indicator of autonomic nervous system activity.

METHOD

This study was conducted with a cross sectional design. This study is to see the difference between heart rate response and heart rate recovery between young high-intensity aerobic athletes who are smokers and non-smokers. The research took place in the training room of the athletes who were the research sample. Sampling in the form of high-intensity aerobic athletes who meet the inclusion criteria and divided into two groups, namely a sample consisting of athletes who smoke and who do not smoke. The research subjects then performed the Harvard Step Test. Inclusion Criteria: 1) High intensity aerobic athletes aged 15 years to 35 years; 2) High-intensity aerobic athletes aged 15 years to 35 years who are willing to participate by signing the consent form after explanation. Exclusion Criteria: 1) Athletes who have a history of heart disease; 2) Athletes who had a resting heart rate of more than 120 beats per minute; 3) Athletes with hypertension; 4) Athletes with a known history of diabetes mellitus or a history of using antidiabetic drugs and or insulin; 5) Athletes with a known history of dyslipidemia or a history of using lipid-lowering drugs.

This Harvard step test uses a 50 cm high bench. Subjects underwent the exercise test going up and down the bench for five minutes at a rate of 30 times per minute or until exhaustion. Subjects were prohibited from smoking, drinking, eating, and doing strenuous physical exercise at least 3 hours before the test. Subjects were rested for 10 minutes, then resting heart rate and resting blood pressure were measured. Furthermore, heart rate was measured at the end of the test, then 1 minute after the test. Blood pressure was also measured after 1 minute after the test was completed.

Data that has been documented will then be analyzed using the SPSS version 24 program. Data analysis is carried out which includes descriptive analysis, comparative test: unpaired t-test, Mann-Whitney test, multivariate analysis with ANCOVA.

RESULT

Based on the characteristics of the study subjects, the median age of the study subjects was 16 years with a p value that was not significant (p=0.294). For body mass index variables, a significantly different value was obtained between the smoker group and non-smokers, where the mean of the smoker group was 20.5 kg/m² while in the non-smoker group was 22.2 kg/m² (p=0.036). In the research subjects obtained for female gender in the smoker group amounted to 2 people and 5 people in the non-smoker group, while for male gender there were 23 people in the smoker group and 20 people in the non-smoker group with a p value that was not significant (p=0.417). In basketball, there were 9 smokers and 8 non-smokers. In badminton there were 14 smokers and 12 non-smokers. In soccer, there were 2 smokers and 5 non-smokers, with a p value that was not significant (p=0.473). For systolic blood pressure variables before the test, the mean was 121.1 mmHg in the smoker group and 119.5 mmHg in non-smokers, with a p value that was not significant (p=0.610). Likewise, for diastolic blood pressure before the test, there was no significant value between the smoker and non-smoker groups with a mean of 72.6 mmHg in smokers and 70.4 mmHg in non-smokers (p=0.258). In the blood pressure examination after the test, the mean systolic blood pressure was 146.6 mmHg in smokers and 145.9 mmHg in non-smokers with a p value that was not significant (p=0.874). Likewise, for diastolic blood pressure after the test obtained results that are not meaningful with a mean of 79.3 mmHg in smokers and 76.1 mmHg in non-smokers (p=0.092).

TABLE 1: Characteristics of Study Subjects Based on Smoker and Non-Smoker Groups.

Variables	Group		P-value
	Smokers N=25	Non-Smokers N=25	
Age (years), median (IQR)	16 (2)	16 (3)	0.294
BMI (kg/m²), mean ± SD	20.5±1.9	22.2±3.5	0.036*
Gender			
Female, n (%)	2 (8.0)	5 (20.0)	0.417
Male, n (%)	23 (92.0)	20 (80.0)	
Type of Sport			
Basketball, n (%)	9 (36.0)	8 (32.0)	
Badminton, n (%)	14 (56.0)	12 (48.0)	0.473
Soccer, n (%)	2 (8.0)	5 (20.0)	0.294

*Statistically significant.

TABLE 2: Heart Rate Characteristics of Study Subjects Based on Smoker and Non-Smoker Groups.

Variables	Group		P-value
	Smokers N=25	Non-Smokers N=25	
Resting heart rate, mean ± SD	75.2±8.0	66.2 ±7.2	<0.001*
Maximal heart rate, mean ± SD	149.5±15.4	147.6±13.5	0.635
1-minute heart rate, mean ± SD	123.2 ±14.6	112.4 ±16.7	0.018*
Heart rate recovery, mean ± SB	26.3 ±8.1	35.2 ±10.9	0.002*

*Statistically significant.

TABLE 3: Blood Pressure Characteristics of Study Subjects Based on Smoker and Non-Smoker Groups.

Variables	Group		P-value
	Smokers N=25	Non-Smokers N=25	
SBP before test, mean ±SD	121.1±11.2	119.5±10.7	0.610
DBP before the test, mean ±SD	72.6±6.5	70.4±6.8	0.258
SBP after the test, mean ±SD	146.6±14.7	147.6±13.5	0.874
DBP after the test, mean ±SB	79.3±6.9	76.1±6.1	0.092

This comparison test is to compare whether there is a difference in resting heart rate, maximal heart rate, heart rate 1 minute after completion of the test, and heart rate recovery between smokers and non-smokers. The results of the comparison test showed that the mean resting heart rate in smokers was significantly higher (75 vs 66, p<0.001).

The mean maximal heart rate was higher in smokers but with a p value that was not significant (149.5 vs 147.6, p=0.635). Mean heart rate 1 minute after the test was found to be significantly higher in smokers (123 vs 112, p=0.018). Results can be seen in Table 2 and Figure 1.

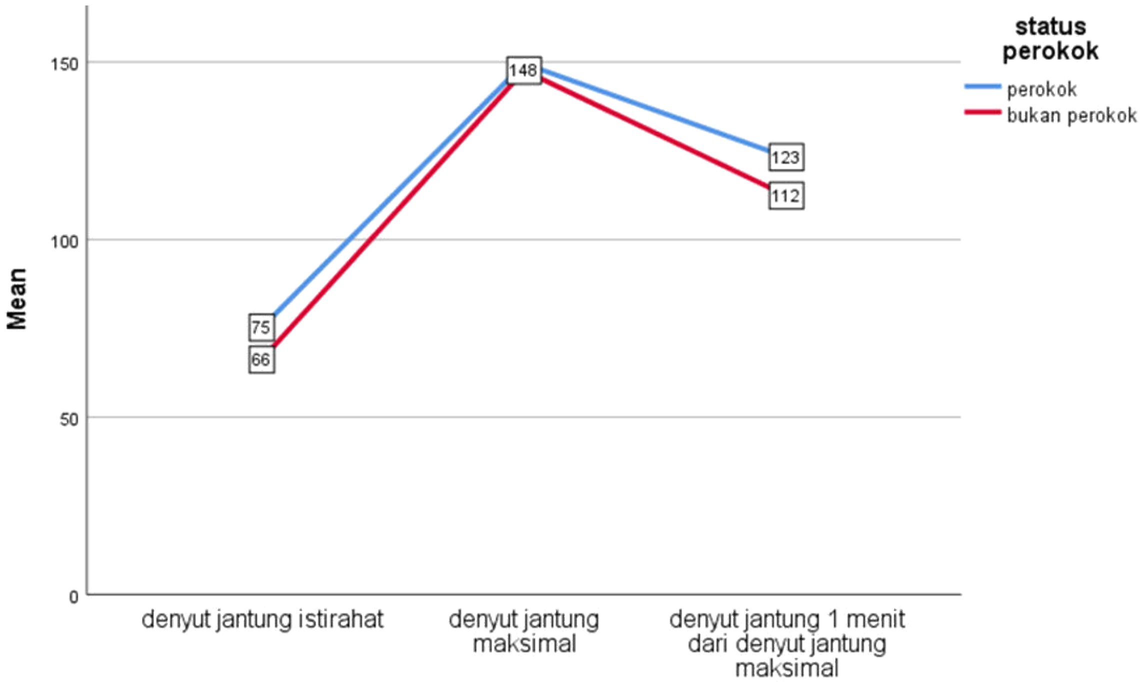

FIGURE 1: Comparison of Resting Heart Rate, Maximal Heart Rate, Heart Rate 1 Minute After Test Between Young Smokers and Non-Smokers of High Intensity Aerobic Athletes.

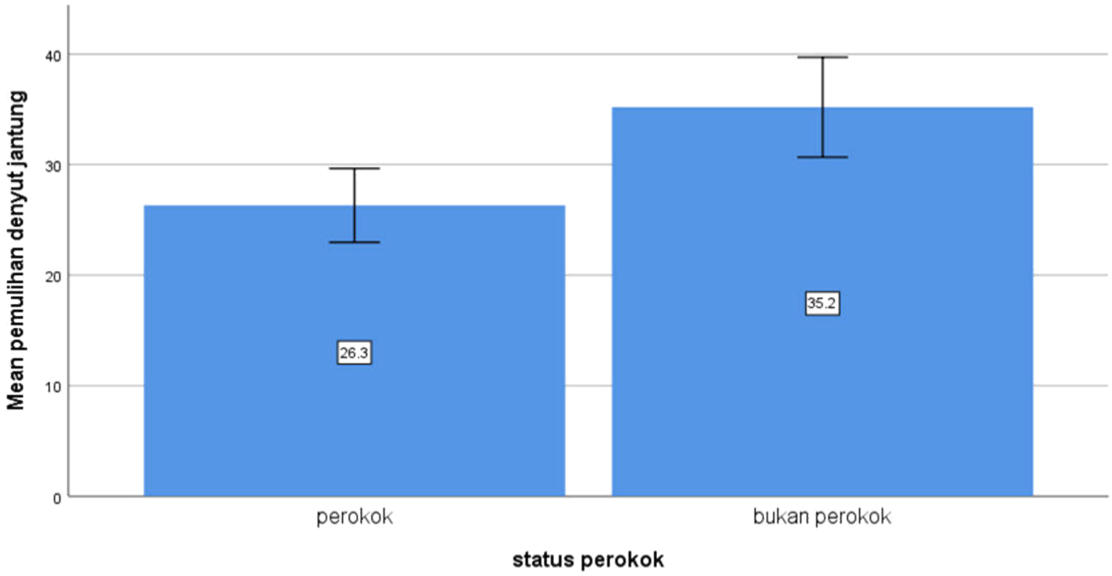

FIGURE 2: Comparison of Mean Heart Rate Recovery Between Young Smokers and Non-Smokers of High Intensity Aerobic Athletes.

For the heart rate recovery variable between the smoker and non-smoker groups, the mean was significantly lower in the smoker group (26.3 vs 35.2, p=0.002) as can be seen in Table 2 and Figure 2.

This multivariate analysis was conducted to identify independently associated factors as determinants of resting heart rate, maximal heart rate, heart rate 1 minute after test, and heart rate recovery between smoking and non-smoking high-intensity aerobic athletes. Multivariate analysis was performed using ANCOVA. Table 4-7 shows the multivariate analysis.

TABLE 4: ANCOVA Test Results Comparison of Resting Heart Rate Responses Between Smoking and Non-Smoking Young High Intensity Aerobic Athletes.

Variables	Koef B	95% CI	P-value
Smokers	9.1	4.440-13.842	<0.001*
Gender	0.005	-6.469-6.580	0.986
Age	-0.320	-0.967-0.328	0.325
IMT	-0.064	-0.921-0.792	0.880

*Statistically significant.

TABLE 5: ANCOVA Test Results Comparison of Maximal Heart Rate Response Between Smokers and Non-Smokers of Young High Intensity Aerobic Athletes.

Variables	Koef B	95% CI	P-value
Smokers	4.511	-3.492-12.514	0.262
Gender	-0.419	-11.527-10.689	0.940
Age	-1.247	-2.349--0.144	0.028
IMT	-1.386	-2.845-0.072	0.062

TABLE 6: ANCOVA Test Results Comparison of 1-Minute Heart Rate Response of Maximal Heart Rate Between Young Smokers and Non-Smokers of High Intensity Aerobic Athletes.

Variables	Koef B	95% CI	P-value
Smokers	11.513	1.883-21.143	0.020*
Gender	0.495	-12.871-13.860	0.941
Age	-0.642	-1.969-0.685	0.335
IMT	-0.386	-2.141-1.368	0.660

*Statistically significant.

TABLE 7: ANCOVA Test Results Comparison of Heart Rate Recovery Between Smokers and Non-Smokers of Young High Intensity Aerobic Athletes.

Variables	Koef B	95% CI	P-value
Smokers	-7.002	-12.467--1.537	0.013*
Gender	-0.913	-8.498-6.671	0.809
Age	-0.605	-1.358-0.148	0.113
IMT	-1.000	-1.996--0.004	0.049

*Statistically significant.

ANCOVA analysis showed that the mean resting heart rate of smokers was 9 times/minute higher than that of non-smokers. The mean maximum heart rate of smokers was 4.5 times/minute higher with no significant value. For the mean heart rate 1 minute after the test 11.5 times/minute was higher in smokers with a significant value. While for the average recovery heart rate of smokers 7 times/minute lower with a significant value. Then covariate analysis of age, gender, and body mass index did not simultaneously affect the value of resting heart rate, maximum heart rate, heart rate 1 minute after the test, and heart rate recovery between young high-intensity aerobic athletes smokers and non-smokers ($p>0.05$).

DISCUSSION

In this study, it was found that the median age of the research subjects was 16 years. Research conducted by Longo et al using data from the date of birth of 2012 Olympic athletes in the UK found that the age range of athletes was from 14 to 52.8 years old, where 72% of the athletes were aged between 20 to 30 years. For Indonesia itself, the median age of Olympic athletes in 2012 was 23.5 years [12].

For the average body mass index in the study subjects, the value was 20.5 kg/m^2 in the smoker group and 22.2 kg/m^2 in non-smokers which is a normal body mass index. Research by Nudri et al with a cross sectional method using male samples aged 18 to 44 years and dividing the subjects into three groups, consisting of 83 athletes, 80 subjects who actively exercise at least 30 minutes per day at least 3 times per week, and 80 sedentary subjects obtained an average body mass index in each group was 22.6±2.9 kg/m^2 , 23.4±3.5 kg/m^2, and 24.3±4.6 kg/m^2 with significant values ($p<0.001$) [13]. Research conducted by Setiowati, using a sample of high school basketball athletes Terang Bangsa Semarang aged 15-18 years, obtained the average body mass index of the sample in his research was 21.60±3.57 kg/m ^{2}[14]. Research by Macera C.A et al who examined US army personnel who smoke and non-smokers found that smokers tend to be younger with a lower body mass index. In addition, smokers have a slower 1.5 mile run time [15].

In this study, the mean systolic blood pressure in the research subjects before the Harvard Step Test was 121.1 mmHg in the smoker group and 119.5 mmHg in non-smokers. For diastolic blood pressure before the test obtained an average of 72.6 mmHg in the smoker group and 70.4 mmHg in non-smokers.

Research by Berge et al with a systematic review method of several studies reporting blood pressure in athletes with more than 100 subjects, with an average or median age of 18 to 40 years found that the average systolic blood pressure varied from 109±11 to 138±7 mmHg and mean diastolic blood pressure from 57±12 to 92±10 mmHg [16].

In this study, it was found that the resting heart rate of athletes who smoked was significantly higher than athletes who did not smoke. Research conducted by Papathanasou et al also found that smokers had a significantly higher resting heart rate than non-smokers. The study used 298 young adults, aged 20-29 years, who were selected from a broad population based on health status, body mass index, physical activity, and smoking habits. All samples underwent a maximal Bruce treadmill test and their heart rate was recorded during the test, at the peak of the test, and after the test. The study found that female smokers had a higher resting heart rate of 76.4 beats per minute than non-smokers' resting heart rate of 70 beats per minute, with $p=0.001$. Similarly, male smokers also had a higher resting heart rate than non-smokers (72.8 vs 66.3, $p=0.004$) [17].

Similarly, a previously published study by Al-Safi using healthy adult samples, most of which were students selected from various regions in Jordan, and blood pressure and heart rate checks were carried out three times at 10-15 minute intervals in sitting and resting conditions. Samples who were smokers, defined as having smoked for more than 6 months, were also asked how many cigarettes they smoked during the day. Resting heart rate in smokers is higher than in non-smokers, as well as the more the number of cigarettes smoked in a day has a higher resting heart rate. Another study conducted by Kobayashi et al on the effects of smoking on cardiorespiratory response to submaximal exercise also found that the resting heart rate of smokers was higher than non-smokers (73 vs 61, $p=0.03$)[18].

Smoking is associated with autonomic dysfunction and with selective changes in cardiac autonomic control. More specifically, nicotine in cigarettes acts on peripheral sympathetic sites, and increases circulating catecholamine levels, and causes a decrease in vagal drive. This more dominant sympathetic activity is also associated with impaired baroreflex function, resulting in a marked increase in resting heart rate.

In this study, the results showed that heart rate 1 minute after the test was significantly higher in smokers than non-smokers. While the maximum heart rate was also higher in smokers but with a value that was not significant. Heart rate recovery 1 minute after the Harvard Step Test is significantly lower in smokers. In a study conducted by Papathanasiou et al found that there was a significantly lower maximal heart rate in smokers compared to non-smokers, but this was only found in female samples. However, the study obtained a higher and faster decrease in heart rate in the first minute after the test was completed in the non-smoking group, both in women and men [17].

In a study conducted by Erat et al, using a sample size of 179 healthy people, consisting of 67 non-smokers and 112 smokers, with exclusion criteria for hypertension, diabetes, and known heart disease. All subjects were given a maximal Bruce treadmil test. Heart rate recovery at the 1st, 2nd, 3rd, and 5th minutes after the maximal test was calculated and compared between the smoker and non-smoker samples. The heart rate recoveries at the 1st, 2nd, 3rd, and 5th minutes were lower in smokers (26.78±8.81 vs 32.82±10.34, p<0.001; 44.37±12.11 vs 51.72 ± 12.87, p<0.001; 52.73 ± 11.54 vs 57.22 ± 13.51, p=0.018; 58.31 ± 10.90 vs 62.33±13.02, p=0.029) [19].

Another study conducted by Jin-Jang et al, using the subject of taekwondo athletes aged 20 to 24 years, divided into smokers as many as 9 people and non-smokers as many as 6 people. Subjects were given CPET (Cardiopulmonary exercise testing), and heart rate recovery 1 minute, 3 minutes, and 5 minutes after maximal exercise was measured and analyzed. It was found that the 1st and 3rd minute heart rate recovery was significantly lower in smokers (p=0.02 and p=0.01, respectively [20].

In the first few minutes of recovery, the heart rate will decrease according to the parasympathetic response of the sinoatrial node. Heart rate recovery is the difference between maximal heart rate and heart rate during recovery at a certain minute and can be used as a predictor in the treadmill training test is 1 minute and 2 minutes heart rate recovery. The normal value of 1-minute heart rate recovery is ≥12 beats per minute for standing recovery or ≥18 times per minute if the recovery is directly lying down/passive. While the normal value for a 2-minute heart rate recovery is 22 times per minute when the recovery phase is in a sitting position [21].

An abnormal recovery heart rate is associated with the subject's prognosis, especially in subjects with an ischemia response in the training test. In patients with abnormal 1-minute HRR (<12 beats/minute) and with moderate-risk Duke Treadmill Score (DTS), the mortality rate was 4.16 (95% CI 3.33-5.19) times that of normal HRR, while in subjects with high-risk DTS, the mortality risk was 4.28 (95% CI 3.43-5.35). Another cohort study showed that a 1-min HRR < 18 increased the risk of death within 3 years 2.09 times (95 % CI 1.49-2.82),14 while an abnormal 2-min HRR also increased the mortality of patients compared with normal ones [21].

Heart rate recovery is a good indicator of the ability of the circulatory respiration system. Athletes are known to have fast heart rate recovery after maximal exercise training. In this study, it was found that non-smoking athletes had a significantly higher 1-minute heart rate recovery compared to smoking athletes. The higher heart rate in smokers during recovery after maximal exercise indicates that oxygen consumption from the heart muscle is higher, which results in an increased load on the heart, which will reduce the ability to exercise.

This research is an observational study with a cross-sectional design where this research is not able to explain the processes that occur in the object / variable under study and the correlation relationship.

SUMMARY

(1) Resting heart rate and heart rate 1 minute after the test were higher in young high-intensity aerobic athletes who were smokers.
(2) Heart rate recovery is lower in young high-intensity aerobic athletes who are smokers.

ACKNOWLEDGMENTS

All patients, all authors, and all support in papper.

DECLARATIONS

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by Udayana University with the number 1971/UN14.2.2VII.14/LT/2023.

REFERENCES

[1] Pepera G, Panagiota Z. Comparison of heart rate response and heart rate recovery after step test among smoker and non-smoker athletes. African Health Sciences 2021; 21:105–11. https://doi.org/10.4314/ahs.v21i1.15.

[2] Cha KS, Seo MK, Ryu HY, Nam JJ, Sung DJ. Smoking-suppressed heart rate recovery in young male college students who regularly exercised. Iranian Journal of Public Health 2015; 44:1146–7.

[3] Corrales L, Rosell R, Cardona AF, Martín C, Zatarain-Barrón ZL, Arrieta O. Lung cancer in never smokers: The role of different risk factors other than tobacco smoking. Crit Rev Oncol Hematol 2020; 148:102895. https://doi.org/10.1016/j.critrevonc.2020.102895.

[4] Alemu R, Fuller EE, Harper JF, Feldman M. Influence of Smoking on the Location of Acute Myocardial Infarctions. ISRN Cardiol 2011; 2011:1–3. https://doi.org/10.5402/2011/174358.

[5] Asma S, Mackay J, Song SY, Zhao L, Morton J, Palipudi KM, et al. The GATS Atlas. Atlanta, GA: The Hanway Press, London; 2015. https://doi.org/10.1002/cncr.23197.

[6] WHO. Evolution of WHO air quality guidelines. 2017.

[7] Saiphoklang N, Poachanukoon O, Soorapan S. Smoking characteristics and lung functions among university athletes. Scientific Reports 2020; 10:1–6. https://doi.org/10.1038/s41598-020-77248-y.

[8] Unverdorben M, Van Der Bijl A, Potgieter L, Venter C, Munjal S, Qiwei Liang, et al. Effects of different levels of cigarette smoke exposure on prognostic heart rate and rate - Pressure-product parameters. Journal of Cardiovascular Pharmacology and Therapeutics 2008; 13:175–82. https://doi.org/10.1177/1074248408321571.

[9] Kim CS, Kim MK, Jung HY, Kim MJ. Effects of exercise training intensity on cardiac autonomic regulation in habitual smokers. Annals of Noninvasive Electrocardiology 2017; 22:1–9. https://doi.org/10.1111/anec.12434.

[10] Elshazly A, Khorshid H, Hanna H, Ali A. Effect of exercise training on heart rate recovery in patients post anterior myocardial infarction. Egyptian Heart Journal 2018; 70:283–5. https://doi.org/10.1016/j.ehj.2018.04.007.

[11] Jolly MA, Brennan DM, Cho L. Impact of exercise on heart rate recovery. Circulation 2011; 124:1520–6. https://doi.org/10.1161/CIRCULATIONAHA.110.005009.

[12] Longo AF, Siffredi CR, Cardey ML, Aquilino GD, Lentini NA. Age of peak performance in Olympic sports: A comparative research among disciplines. Journal of Human Sport and Exercise 2016; 11:31–41. https://doi.org/10.14198/jhse.2016.111.03.

[13] Wan Nudri WD, Wan Abdul Manan WM, Mohamed Rusli A. Body mass index and body fat status of men involved in sports, exercise, and sedentary activites. Malaysian Journal of Medical Sciences 2009; 16:22–7.

[14] Setiowati A. Hubungan Indeks Massa Tubuh , Persen Lemak Tubuh , Asupan Zat Gizi dengan Kekuatan Otot. Media Ilmu Keolahragaan Indonesia 2014; 4:1.

[15] Macera CA, Aralis HJ, MacGregor AJ, Rauh MJ, Han PP, Galarneau MR. Cigarette Smoking, Body Mass Index, and Physical Fitness Changes Among Male Navy Personnel. Nicotine & Tobacco Research 2011; 13:965–71. https://doi.org/10.1093/ntr/ntr104.

[16] Berge HM, Isern CB, Berge E. Blood pressure and hypertension in athletes: A systematic review. British Journal of Sports Medicine 2015; 49:716–23. https://doi.org/10.1136/bjsports-2014-093976.

[17] Papathanasiou G, Georgakopoulos D, Papageorgiou E, Zerva E, Michalis L, Kalfakakou V, et al. Effects of smoking on heart rate at rest and during exercise, and on heart rate recovery, in young adults. Hellenic Journal of Cardiology 2013; 54:168–77.

[18] Al-Safi SA. Does smoking affect blood pressure and heart rate? European Journal of Cardiovascular Nursing 2005; 4:286–9. https://doi.org/10.1016/j.ejcnurse.2005.03.004.

[19] Erat M, Doğan M, Sunman H, Asarcıklı LD, Efe TH, Bilgin M, et al. Evaluation of heart rate recovery index in heavy smokers. Anatolian Journal of Cardiology 2016; 16:667–72. https://doi.org/10.5152/AnatolJCardiol.2015.6500.

[20] Jang DJ, Kim HC, Kim JK, Jung SY, Kim DY. Effects of habitual smoking on cardiopulmonary function in taekwondo athletes. Journal of Exercise Rehabilitation 2017; 13:711–5. https://doi.org/10.12965/jer.1735172.586.

[21] Radi B et al. Pedoman Uji Latih Jantung. Perhimpunan Dokter Spesialis Kardiovaskular Indonesia 2016:1–50.