International Journal of Physical Education, Sports and Health 2018; 5(5): 06-12

P-ISSN: 2394-1685
E-ISSN: 2394-1693
Impact Factor (ISRA): 5.38
IJPESH 2018; 5(5): 06-12

www.kheljournal.com
Received: 04-07-2018
Accepted: 08-08-2018

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Effects of smoking on heart rate at rest and during submaximal exercise, heart rate recovery and blood pressure in young adults

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Abstract
Background: Smoking is estimated to cause 10% of cardiovascular disease (CVD) and is the second leading cause of CVD after high blood pressure. The arteries that supply blood to the heart become severely narrowed artery in coronary disease. Adrenaline produced when the nicotine in cigarettes stimulates body, which means heart beat faster and raises blood pressure, making heart to work harder.
Objective: To investigate the differences of cardiac function in smokers and non-smokers.
Design: Observational study,
Method: A total of 40 (20 smokers and 20 non-smokers) samples are choose based on purposive sampling method with the age range of 18 to 24 years old male and healthy weight Body Mass Index (BMI). Subjects with low physical activity profile are screened with International Physical Activity Questionnaire (IPAQ-short). Before the patient is asked to run on treadmill until sub maximal effort, heart rate and blood pressure is measured after 10 minutes of rest. During treadmill running, heart rate will be measured each minute using pulseoximeter. After the patient underwent recovery period for 5 minutes, heart rate and blood pressure measured again.
Results: In the present study, smoking was found to effect resting heart rate (79.45 ± 2.78 and 73.40 ± 2.30) in young male smokers compares with non-smokers. Resting systolic blood pressure shows a significant difference between smokers and non-smokers (129.10 ± 4.17 and 120.25 ± 3.18) and resting diastolic blood pressure also found to have statistical significant different between smokers and non-smokers (85.50 ± 3.32 and 77.65 ± 3.00). Our study shows that smokers had found no significant difference in heart rate during sub maximal exercise compared with non-smokers (119.40 ± 1.14 and 119.35 ± 1.09) and attenuated heart rate decline during heart rate recovery (84.40 ± 2.95 and 76.10 ± 3.49) in smokers and non-smokers. Recovery systole (155.65 ± 3.33 and 144.25 ± 4.20) and diastole (107.45 ± 4.62 and 104.05 ± 5.23) blood pressure is also having slower decline in smokers compared with non-smokers.
Conclusion: This study proves that resting heart rate in smokers is higher than non-smokers. Systolic and diastolic blood pressure also appears higher value in smokers compares with non-smokers. Heart rate during sub maximal workload shows no statistically significant difference between smokers and non-smokers. Recovery heart rate in smokers declines attenuated when compares with non-smokers. Systolic and diastolic blood pressure shows higher value in smokers than in non-smokers.

Keywords: smoking, heart rate, during submaximal, blood pressure, young adults

Introduction
World Health Organization states tobacco epidemic is one of the biggest public health threats to the world which has ever faced. Nearly 6 million people a year and more than 600,000 of those deaths are the results of non-smokers being exposed to second-hand smokers while more than 5 million of those deaths are the results of direct tobacco use. Accounting for one in 10 adults' deaths, approximately one person dies every 6 seconds due to tobacco. More than 40% of Malaysian man smoke or a total of 4.7 million adult smokers and smoking is being a major cause of coronary heart disease which leads to heart attack. Risk of death is higher when the heart rate is high at rest even in fit healthy people. The risk of death increased by 16% overall at every 10 to 22 additional beats per minute in resting heart rate. When smoking was factored in, risk of death increase by 20% for every 12 to 27 additional heartbeats compared with 14% risk of death of non-smokers for every additional 4 to 24 beats per minutes. Arteries and heart

seriously damaged by high blood pressure. High blood pressure damages cells of arteries inner lining and also narrows the arteries. The constant pressure of blood passing through a weakened artery causing a section of its wall to enlarged and form aneurysm. High blood pressure forces heart muscle to work harder than usual where the left ventricle is enlarged. Heart begins to wear out and fail when the strain on heart muscle increases causing it weak and work less efficient leads to heart failure [3].

Method and Procedure

Study design: Observational study
Study location: WIT College, Pelabuhan Klang
Study duration: 11 months
Intervention duration: 4 weeks
Sampling Method: Purposive sampling method

Inclusion criteria

- Age: 18-24 years old
- Body Mass Index: healthy weight (18.5-24.9)
- Low physical activity profile
- Smokes at least 10 cigarettes per day for at least three smoking years

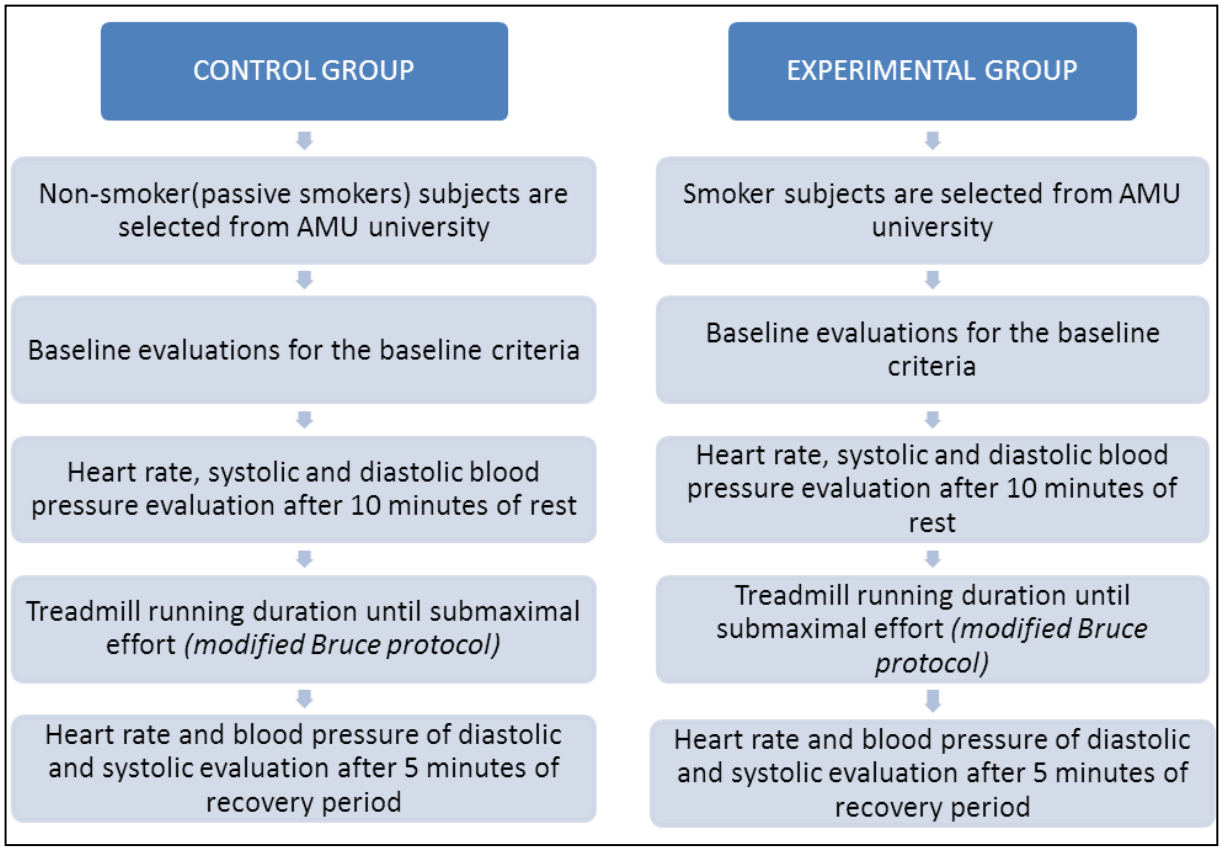
Exclusion criteria

- Abnormal blood pressure
- Abnormal resting heart rate
- Having cardiovascular disease
- Having lung disease
- Excessive consumption of coffee or alcohol
- Drug consumption
- Lower limb injury

Procedure

A total of 40 (20 smokers and 20 non-smokers) samples are choose based on purposive sampling method with the age range of 18 to 24 years old male and healthy weight Body Mass Index (BMI). Subjects with low physical activity profile are screened with International Physical Activity Questionnaire (IPAQ-short).Before the patient is asked to run on treadmill until sub maximal effort, heart rate and blood pressure is measured after 10 minutes of rest. During treadmill running, heart rate will be measured each minute using pulse oximeter. After the patient underwent recovery period for 5 minutes, heart rate and blood pressure measured again.

Study methodology



Technique of data collection

Before experiment: Subject will be selected based on age (18-24 years old), having low physical activity profile (International Physical Activity Questionnaire (IPAQ-short)). Experimental group (smokers): no of cigarettes smoke per day (at least 10 cigarettes), smoking years (3 years and above). Control group (non-smoker): had never smoke. Height and weight of the subject will be measured to calculate the Body Mass Index (BMI) of the subject. The score of BMI should be normal ($18.5kg/m^2 \leq BMI \geq 24.9kg/m^2$) Subject will be instructed to sit on a supported chair for 10 minutes before heart rate and blood pressure taken. Those measurements are considered as baseline measurement. Resting heart rate should be in between 60 to 100. Systolic blood pressure measurement should be in between 100 to 140 and diastolic blood pressure measurement should be in between 60 to 90. Target heart rate (THR) will be calculated before the experiment (60% from the maximum heart rate) while maximum heart rate will be calculated 220-age. Subject will be rejected if the baseline measurement does not fall under normal range, having cardiovascular disease or lung disease, excessive consumption of coffee (≤ 2 cups per day) or alcohol (≤ 7 drinks per day) or having any recent lower limb injury.

During experiment: Subjects should avoid heavy eating, coffee and alcohol and smokers from smoking for at least 6 hours before the exercise test. Explanation is given to the subjects before the procedure started. Heart rate monitor is set before the exercise test started. Exercise test will be started with the Modified Bruce protocol and heart rate of the subject will be measured each minute. Exercise test will be terminated when target heart rate is reached.

After experiment: After subject reach his target heart rate, subject is instructed to sit on a back supported chair for 5 minutes. After 5 minutes, heart rate and blood pressure will be measured.

Statistical tools: This research design used independent t-test to compare the data of resting heart rate, resting systole and diastole blood pressure, submaximal heart rate, recovery heart rate and recovery systole and diastole blood pressure between smokers and non-smokers group.

Data analysis: The data is taken equally from all 40 male subjects. Resting heart rate and blood pressure is taken 10 minutes after the subject rest. Sub maximal exercise heart rate data is taken each minute the subject on treadmill until the subject reaches his target heart rate and recovery heart rate and blood pressure is taken 5 minutes after the subject rest.

Data interpretation: Statistical analysis for this study is done by using the statistical software SPSS 18.0 version. An independent t-test was used as the statistical tool to compare the results between control group and experimental group. The probability value for this study is less than 0.05 ($P<0.05$) which is considered as statistically significant.

Table 1: Mean and standard deviation of demographic data of non-smokers

Non-smokers	Mean	Standard deviation
Age	20.9	1.59
Body Mass Index (kg/m²)	21.3	1.95
Exercise Test Duration (min)	14.6	2.58

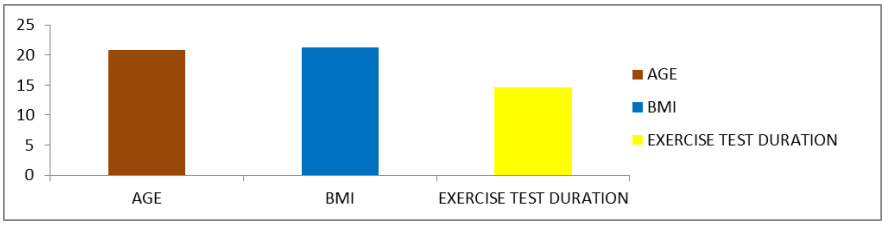


Fig 4: Mean of demographic data of non-smokers

Table 2: Mean and standard deviation of demographic data of smokers

Smokers	Mean	Standard deviation
Age	20.5	1.82
Body Mass Index (kg/m²)	20.7	1.29
Smoking Years	6.3	2.66
Exercise Test Duration (min)	11.0	0.79

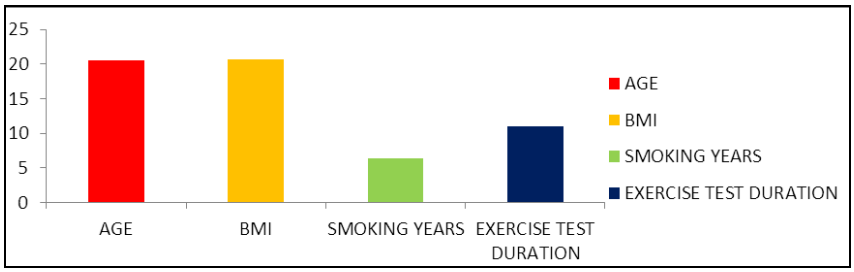


Fig 5: Mean of demographic data of smokers

Table 3: Resting heart rate, resting systolic and diastolic blood pressure on smokers and non-smokers

	Significance				
	Non-smokers (n=20)	Smokers (n=20)	t-value	P	(95% CI)
Resting Heart Rate	73.40±2.30	79.45±2.78	7.49	.000	(4.42 to 7.69)
Resting Blood pressure (systolic)	120.25±3.18	129.10±4.17	7.55	.000	(6.48 to 11.23)
Resting Blood pressure (diastolic)	77.65±3.00	85.50±3.32	7.86	.000	(5.83 to 9.87)

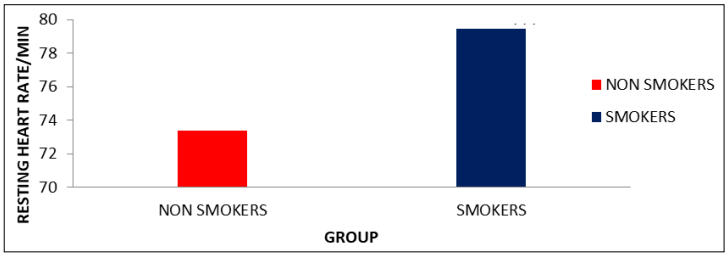


Fig 6: Resting heart rate on smokers and non-smokers

In this study, the independent t-test is used to find out the difference between the graphs. Degree of freedom for RHR on smokers and non-smokers is t (38) = 7.49. For p<0.05 is 0.000 which shows there is statistical difference there by rejecting null hypothesis.

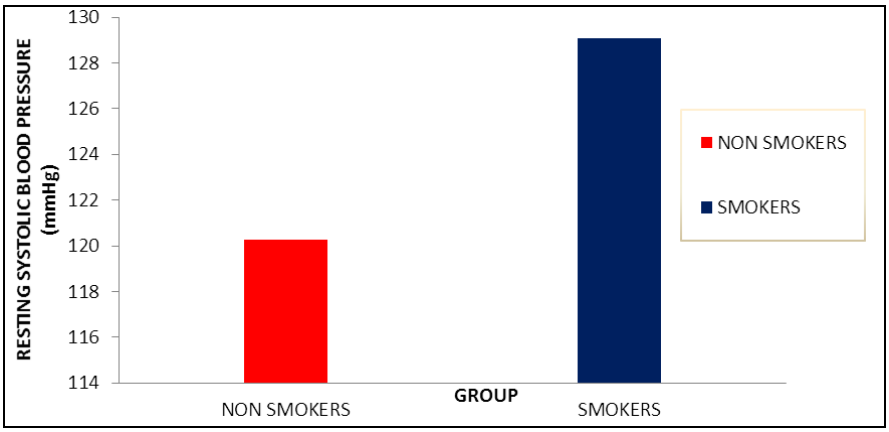


Fig 7: Resting systolic blood pressure on smokers and non-smokers

In this study, the independent t-test is used to find out the difference between the graphs. Degree of freedom for SBP on smokers and non-smokers is t (38) = 7.55. For p<0.05 is 0.000 which shows there is statistical difference there by rejecting null hypothesis.

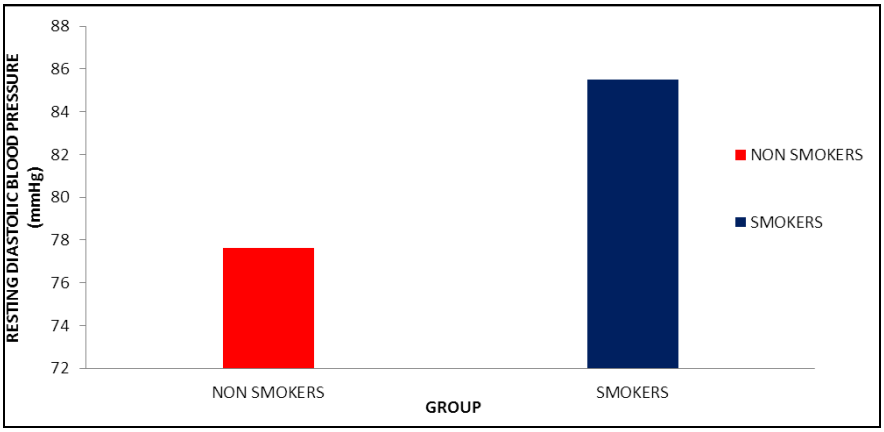


Fig 8: Resting diastolic blood pressure on smokers and non smokers

In this study, the independent t-test is used to find out the difference between the graphs. Degree of freedom for DBP on smokers and non-smokers is t (38) = 7.86. For p<0.05 is 0.000 which shows there is statistical difference there by rejecting null hypothesis.

Table 4: Sub maximal heart rate on smokers and non-smokers

			Significance		
	Non-smokers (n=20)	**Smokers (n=20)**	**t-value**	**p**	**(95% CI)**
Sub maximal Heart Rate	119.35±1.09	119.40±1.14	0.14	0.89	(-0.67 to 0.77)

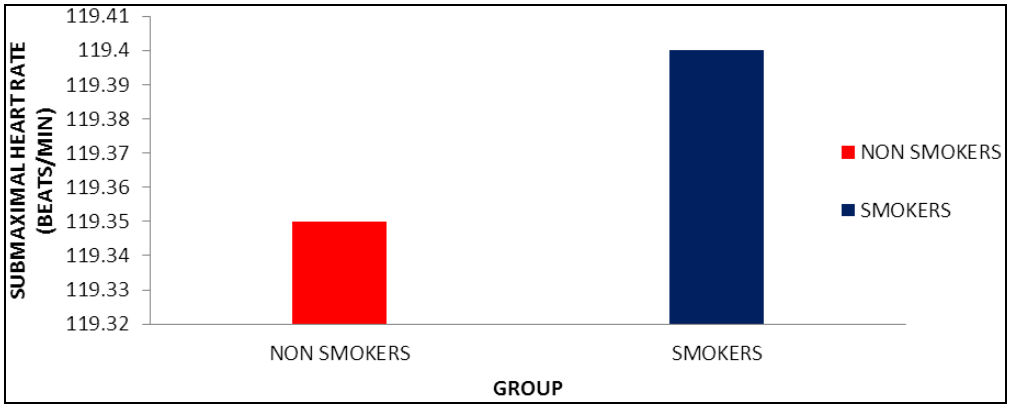


Fig 9: Sub maximal heart rate on smokers and non-smokers

In this study, the independent t test is used to find out the difference between the graphs. Degree of freedom for sub maximal heart rate smokers and non-smokers is t (38) = 0.14. For P > 0.05 is 0.89 which shows there is no statistical difference there by accepting null hypothesis

Table 5: Recovery heart rate, systolic and diastolic blood pressure on smokers and non-smokers

			Significance		
	Nonsmokers (n=20)	**Smokers (n=20)**	**t-value**	**p**	**(95% CI)**
Recovery Heart Rate	76.10±3.49	84.40±2.95	8.12	0.000	(6.23 to 10.37)
Recovery Blood pressure (systolic)	144.25±4.20	155.65±3.33	9.51	0.000	(8.97 to 13.83)

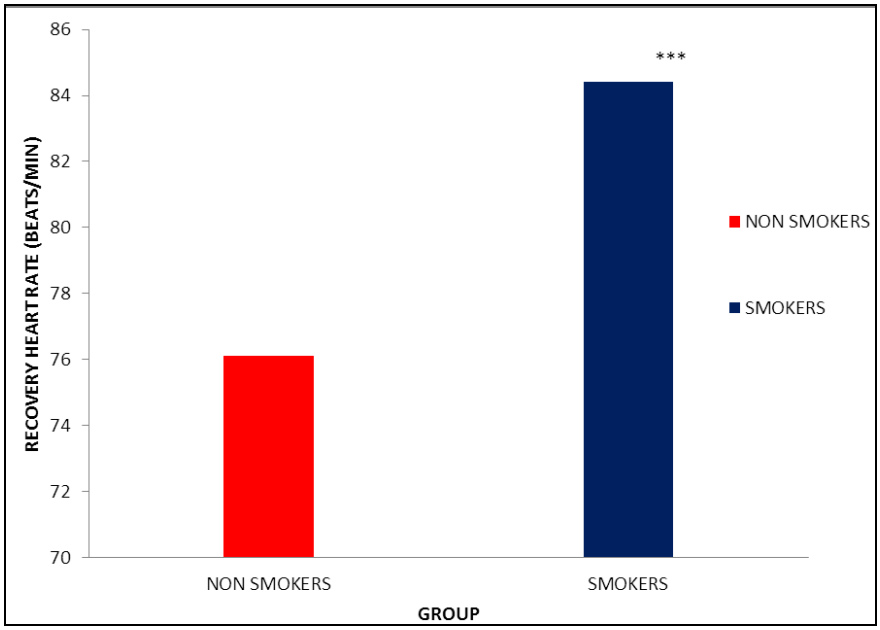


Fig 10: Recovery heart rate on smokers and non-smokers

In this study, the independent t test is used to find out the difference between the graphs. Degree of freedom for recovery heart rate smokers and nonsmokers is t (38) = 8.12. For P < 0.05 is 0.00 which shows there is statistical difference there by rejecting null hypothesis.

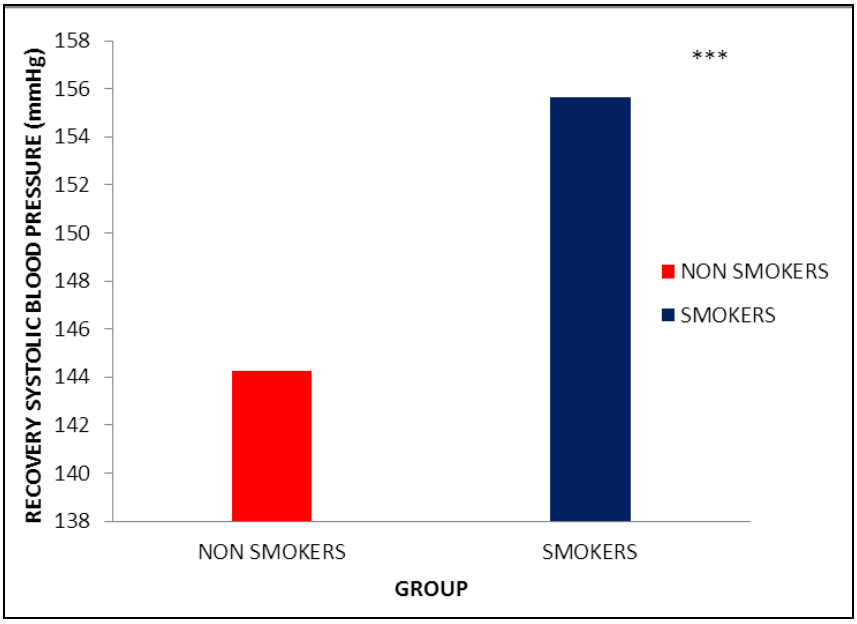


Fig 11: Recovery systolic blood pressure on smokers and non-smokers

In this study, the independent t test is used to find out the difference between the graphs. Degree of freedom for recovery blood pressure (SBP) smokers and nonsmokers is t (38) = 9.51. For P<0.05 is 0.00 which shows there is statistical difference there by rejecting null hypothesis.

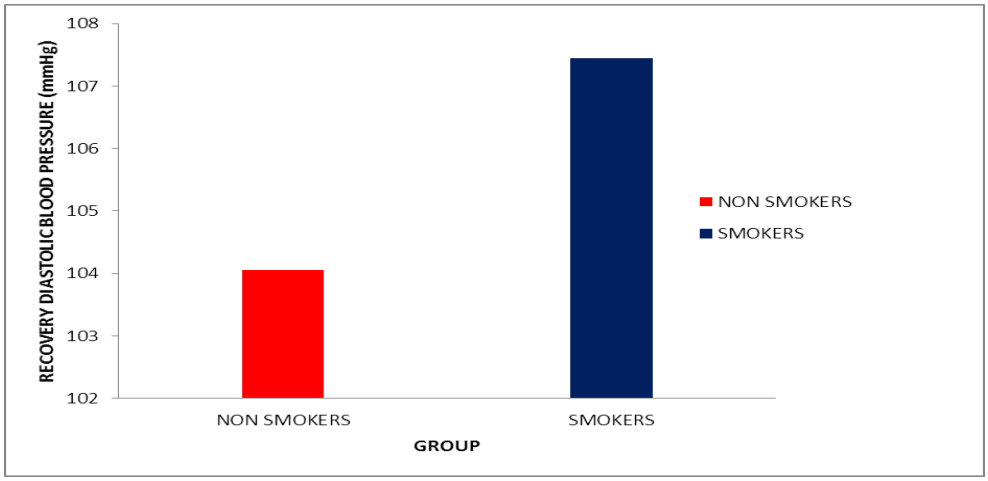


Fig 12: Recovery diastolic blood pressure on smokers and non-smokers

In this study, the independent t test is used to find out the difference between the graphs. Degree of freedom for recovery blood pressure (DBP) smokers and nonsmokers is t (38) = 2.18. For P<0.05 is 0.04 which shows there is statistical difference there by rejecting null hypothesis.

Discussion

According to the latest WHO data published in May 2014 Coronary Heart Disease Deaths in Malaysia reached 29,363 or 23.10% of total deaths. The age adjusted Death Rate is 150.11 per 100,000 of population ranks Malaysia number 33 in the world [2]. The chemicals in tobacco smoke harm blood cells. They also can damage the function of the heart and the structure and function of the blood vessels. This damage increases the risk of atherosclerosis. In the present study, smoking was found to effect resting heart rate and blood pressure in young male smokers. Smokers had faster increase heart rate during sub maximal exercise compared with non-smokers and attenuated heart rate decline during heart rate recovery. Recovery systole and diastole blood pressure is having slower decline in smokers compared with non-smokers.

Heart Rate

Our studies data shows that resting heart rate in smokers appears significantly higher than the non-smokers. These results are similar with previously published data [2, 25, 32, 35]. They are likewise in concurrence with numerous heart rate related studies, where smoking has been connected with increased resting heart rate value. [19, 20] Both sympathetic and parasympathetic incitements follow up on sino atrial hub, the pacemaker of heart, which decides the heart rate. On vagotomy, the thoughtful drive acts unopposed and expands the heart rate to around 150/min. interestingly, on sympathectomy, the heart pulsates at a rate of 60/min, driven exclusively by vagal release. Smoking harms the lining of the arteries, prompting a development of greasy material (atheroma) which contracts the course. The carbon monoxide in tobacco smoke diminishes the measure of oxygen in blood. This implies heart needs to pump harder to supply the body with the oxygen it needs. The nicotine in cigarettes invigorates body to deliver adrenaline, which makes heart beat quicker and raises circulatory strain, making heart work harder. Increased heart rate value during workload depends on the intensity of the workload. The more the intensity of the workload, there will be more increase in heart rate. During workload, muscles require a lot of vitality. Despite the fact that the muscles can get some vitality via doing anaerobic metabolic system, as the workload continues muscle requires aerobic metabolic system, which can't be finished without oxygen. Since circulation system is in charge of conveying the oxygen to muscles, heart needs to pump an incredible measure of blood for keeping up the oxygen supply to the muscles that are working. To satisfy this objective, the heart begins beat quickly and accommodatingly, which increases the heart rate during exercise. There is no statistically significant difference on heart rate at submaximal exercise between smokers and non-smokers but our data shows that smokers reached their target heart rate faster when compares with non-smokers. An altered sensitivity in autonomic neural control from cigarette smoking may inhibit the heart rate response of smokers to sub maximal exercise [36] causing there is no significant difference in results in sub maximal heart rate of smokers and non-smokers.These results cannot be proven because there is confusion between the previous studies states there is more increase in smokers heart rate on sub maximal exercise compares with non-smokers [23, 29], some other studies states that smokers having lower heart rate at submaximal exercise [26, 34] meanwhile other studies states that there is no significant difference between smokers and non-smokers [25,. 33]. There should be more studies done on comparing submaximal heart rate between smokers and non-smokers. Abnormal heart rate recovery (HRR) has been shown to predict mortality. Weakened recovery heart rate always related to heart disease. As our study shows, smokers having attenuated recovery heart rate compared with non-smokers.

Blood Pressure

Force that applied on the arterial walls as the heart pumps blood is known as blood pressure. The left ventricle that having rhythmic contractions results in cyclic changes in arterial blood pressure. During ventricular systole, the pressure created by the blood reaches its highest level, systolic blood pressure while during diastole, the pressure at its lowest level, known as diastolic blood pressure. Our study shows that there is significant different in resting systolic and diastolic blood pressure between smokers and non-smokers. After the termination of the exercise, recovery blood pressure also shows significant different between smokers and non-smokers. Some previous studies supports that there will be increase blood pressure in smokers when compares with non-smokers and they also agrees that there will be weaken recovery blood pressure in smokers [28, 30, 31].

Conclusion

This study proves that resting heart rate in smokers is higher than non-smokers. Systolic and diastolic blood pressure also appears higher value in smokers compares with non-smokers. Heart rate during sub maximal workload shows no statistically significant difference between smokers and non-smokers. Recovery heart rate in smokers declines attenuated when compares with non-smokers. Systolic and diastolic blood pressure shows higher value in smokers than in non-smokers.

Limitations and recommendations

Limitations

- Small sample size.
- Short duration of the study.
- No double blinding design in this study.

Recommendations

- Increase sample size.
- More studies should be done to analyze effect of smoking on heart rate during sub maximal exercise.

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