Indian Journal of Clinical Anatomy and Physiology 2021;8(1):69–73

Content available at: https://www.ipinnovative.com/open-access-journals

Indian Journal of Clinical Anatomy and Physiology

Journal homepage: https://www.ijcap.org/

Original Research Article

The effect of smoking on the cardiovascular autonomic functions tests

Tejashwini Basarigidad[1,*], Ganashree C P[1]

[1] *Dept. of Physiology, Basaveshwara Medical College, Chitradurga, Karnataka, India*

ARTICLE INFO

Article history:
Received 18-03-2021
Accepted 22-03-2021
Available online 12-04-2021

Keywords:
Cardiovascular autonomic function tests
Smokers
Non smokers
resting heart rate
Resting heart rate

ABSTRACT

Background: Tobacco smoking is one of the major causes of preventable morbidity and mortality all over world. Smoking affects the cardiovascular system by several mechanisms. The present study was planned to study the effect of smoking on the cardiovascular autonomic functions among smokers.

Materials and Methods: This study comprises 50 male subjects aged between 20 to 30 years, who included 25 smokers who formed cases and 25 non-smokers who formed the control groups were selected for this study. The design for this study is cross-sectional survey. The subjects were from patients who attended medicine OPD. Inclusion and exclusion criteria are followed in selecting participants. 1: Prior informed written consents were obtained from them after explaining to them, the procedure and the purpose of the study tests; 2. Ethical approval was taken from ethical committee of BMCH, Chitradurga.

The cardiovascular autonomic function tests were assessed by using a CANWIN AUTONOMIC ANALYSER which was available in the department.

Results: In our study, it was observed that there was significant difference between the mean values of the para-sympathetic function tests among the smokers and the non-smokers (i.e. $p<0.01$) The Resting Heart Rate had significantly increased and the Expiration: Inspiration Ratio, the 30:15 Ratio (Response to standing) and the Valsalva Ratio had significantly decreased in the smokers as compared to those in the non-smokers.

In this study, it was observed that there was no significant difference between the mean values of the Postural hypotension test (i.e. $p>0.05$) and that there was a highly significant difference between the mean values of the Sustained handgrip test in the smokers and the non-smokers (i.e. $p<0.01$).

Conclusion: The Resting Heart Rate had significantly increased in case of smokers as compared to non-smokers due to increased sympathetic activity due to release of catecholamines. The Expiration: Inspiration Ratio, 30:15 Ratio (Response to standing) and the Valsalva Ratio had significantly decreased in the smokers as compared to those in the non-smokers due to derangement in parasympathetic activity.

In sustained handgrip test, rise in blood pressure is decreased in smokers as compared to non-smokers due to reduced sympathetic activity.

1. Introduction

Tobacco smoking is one of the major causes of preventable morbidity and mortality all over world.[1]

Cigarette smoking kills nearly 5 million people annually globally. The WHO estimated that tobacco smoking killed nearly 100 million people worldwide in the 20th century.

Nearly about 17% smokers in the world live in India.[2] Presently, nearly 2200 people per day and 9 lakhs every year die in India due to tobacco related diseases. The Health department has stated that 40% of India's health problems are related to tobacoo use. The health and lifestyle factors, together with the genetic makeup of an individual, determine the response to these changes.[3] Heavy cigarette smoking is one of the major causes for the development of ischaemic heart disease and death in younger age group.

* *Corresponding author.*
E-mail address: teju23091987@gmail.com (T. Basarigidad).

https://doi.org/10.18231/j.ijcap.2021.016

There are several mechanisms by which smoking affects the cardiovascular system. The haemodynamic effects of smoking appears to be mediated by nicotine. Nicotine increases cardiac output by increasing heart rate and myocardial contractility due to the effect of increased catecholamines. Smoking is also associated with increase in blood pressure. These effects are dependent on the adrenergic stimulation. Smoking impairs the baroreceptor reflex sensitivity in humans, which may contribute to the smoking induced increase in the blood pressure and the heart rate, The autonomic neurohumoral response which is evoked by smoking, results in the down regulation of the beta-adrenergic receptors in long term smokers.[4] Cessation of smoking is associated with reduced cardiovascular mortality and morbidity[5] Autonomic nervous system plays a pivotal role in the regulation of cardiovascular activities[6] and balance between its two components i.e. sympathetic and parasympathetic system is responsible for the efficient control of cardiovascular system.[7–9] Heart rate variability measures the variation in the S-Anode due to sympathovagal change.[10] Smoking is said to increase arterial pressure and heart rate acutely. The acute effect of smoking is mainly due to nicotine while reduction in cardiac vagal tone is responsible for chronic effects. Although smoking increases arterial pressure and heart rate acutely, the effect of smoking on sympathetic activity is not well understood. Classical autonomic function tests are simple non-invasive methods for determination of both sympathetic & parasympathetic divisions of cardiovascular autonomic control in clinical setting. The present cross-sectional study was therefore conducted to assess the effects of cigarette smoking on sympathetic & parasympathetic activity on cardiovascular system.

2. Materials and Methods

1. This study comprises 50 male subjects aged between 20 to 30 years, who included 25 smokers who formed cases and 25 non-smokers who formed the control groups were selected for this study. The subjects were from patients who attended medicine OPD.
2. Prior informed written consents were obtained from them after explaining to them, the procedure and the purpose of the study tests.
3. The design for this study was cross-sectional survey. Ethical approval was taken from ethical committee of BMCH, Chitradurga.

2.1. Inclusion and exclusion criteria

2.1.1. The case group

Smokers who are having history of more than 5 years of smoking are taken for this study and who are having history of less than 5 years of smoking are excluded from this study. And also subjects who are known case of hypertension, type 2 diabetes, peripheral neuropathy, stroke and other cardiovascular diseases are excluded from this study.

2.2. The control group

The subjects who have never smoked in their life and who did not have any other addiction which was related to tobacco and other types of addiction were considered as the control group for the present study. And also subjects who are known case of hypertension, type 2 diabetes, peripheral neuropathy, stroke and other cardiovascular diseases are excluded from this study.

Smoking index is a simple parameter used to assess smoking exposure quantitatively and also useful to assess risk ratio of smoking related diseases.

The smoking index is calculated by multiplying the average number of cigarettes which was smoked per day and the duration of the smoking in years. The number of cigarettes means, the average numbers of cigarettes which was smoked per day in the last seven days.

According to the Smoking Index, the smokers were classified into:

1. Light smokers (Smoking index 1-100)
2. Moderate smokers (Smoking index 101-200)
3. Heavy smokers (Smoking index >201)

The cardiovascular autonomic function tests were assessed by using a CANWIN AUTONOMIC ANALYSER instrument which was available in the department. It was manufactured in Hyderabad, India. Being fully automatic, the need of a manual recording and reading is eliminated. An inbuilt time domain waveform analysis and blood pressure measurements make the task of conducting all the six autonomic functions tests very easy.

The following cardiovascular autonomic function tests were included:

2.3. Parasympathetic function tests

1. The Resting Heart Rate: The subjects are asked to lie down comfortably in supine position for 15 minutes. Then ECG was recorded continuously for 1 minute. The resting heart rate was calculated from the ECG.
2. The Expiration–Inspiration Ratio (E: I Ratio): The subjects are asked to take deep inspirations for 5 seconds, followed by deep expirations for 5 seconds. The ECG was recorded for 3 such cycles. This test is based on the sinus arrhythmia during each respiratory cycle, which depends on the variation in the vagal tone.
3. The 30:15 Ratio: (Response to standing).The subjects were asked to lie down comfortably over the couch and then they were asked to stand up. Their heart rates were recorded at the 15th and 30th beats immediately after standing.

4. The Valsalva Ratio: The subjects are asked to sit comfortably. Their heart rates were recorded at rest, with the ECG. Their noses were clipped with nose clips and mouth pieces were inserted between their teeth and lips. The other ends of the mouthpieces were connected to mercury manometers. The subjects were asked to blow air into the mouthpieces and the pressure was maintained at 40 mmHg for 15 seconds. The ECG was continuously recorded.

The valsalva ratio was calculated as the ratio of the longest RR interval after the strain to the shortest RR interval during the strain.

2.4. Sympathetic function tests

1. The Postural Hypotension Test (Postural challenge test): The subjects were asked to lie comfortably in the supine position for 15 minutes and their blood pressures were recorded. They were then asked to stand up and their blood pressures were recorded immediately and after 1 minute.
2. The Sustained Handgrip Test: The subjects were asked to hold spring dynamometers in their left hands and to compress them maximally and the values were noted. Then they were asked to hold the spring dynamometers in their left hands and to compress them to upto 30% of the maximum and to hold them for 4 minutes. The rise in the diastolic blood pressure at the point, just before the release of the handgrip, was noted. This test is an indicator of the sympathetic insufficiency.

The collected data was analyzed by using the SPSS software which was available in the department.

3. Observations and Results

After applying the 'Z' test for the difference between the two sample means, a statistically significant difference was observed between the mean values of the Para sympathetic function tests in the smokers and the non-smokers (i.e. $p<0.01$) It was observed that the Resting Heart Rate had significantly increased and that the Expiration: Inspiration Ratio, the 30:15 Ratio (Response to standing) and the Valsalva Ratio had significantly decreased in the smokers as compared to those in the non-smokers (Table 1).

After applying the 'Z' test for the difference between the two sample means, no significant difference was observed between the mean values of the Postural hypotension test (i.e. $p>0.05$) and a highly significant difference was observed between the mean values of the Sustained handgrip test in the smokers and the non-smokers (i.e. $p<0.01$).(Table 2)

In Table 3, it can be seen that as far as the para sympathetic function tests were concerned, the values of (1) the Expiration: Inspiration ratio, (2) the 30:15 ratio and (3) the Valsalva ratio went on decreasing as the severity of the smoking (smoking index) increased, thus indicating a greater damage to the parasympathetic system. Also, the resting heart rate values went on increasing with the severity of smoking, thus suggesting a similar effect.

In Table 4, it can be seen that in the postural hypotension test, the fall in the systolic pressure was maximum in the heavy smokers as compared to those in the light and the moderate smokers. Similarly, in the sustained handgrip test, the rise in the diastolic pressure decreased in the heavy smokers as compared to those in the moderate and the light smokers

4. Discussion

Ischaemic heart disease is major cause of morbidity and mortality throughout the world. Use of Tobacco and its products is important cause for development of ischaemic heart disease. Use of tobacco has increased globally specially among youth.

Smoking causes increased stimulation of sympathetic nervous system either due to increased release of catecholamines like norepinephrine, epinephrine and dopamine or reduced clearance of catecholamines from the body. Smoking causes impairment in baroreceptor reflex leading to increased heart rate, blood pressure and increased myocardial contractility. Baroreceptor reflex is very much important in maintaining normal heart rate ,blood pressure but is its impaired in case smokers.

In the present study, after the statistical analysis, there was significant changes seen in the parasympathetic and to some extent, in the sympathetic autonomic function tests in the smokers as compared to those in the non-smokers.

In our study, the resting heart rate was found to be increased in case of smokers as compared to that in the non-smokers and it was statistically significant. The resting heart rate is considered to be a good parameter among all cardiac health and it is mainly governed by the para-sympathetic activity. The resting heart rate is a simple measurement with prognostic implications. The high resting heart rate is a predictor of the total and the cardiovascular mortalities which are independent of other risk factors in the patients with coronary artery disease.[9]

The 30:15 ratio or the response to standing is a parameter which is useful for assessing the reactivity of the para-sympathetic system. In the present study, a decrease in the 30:15 ratio was found in smokers as compared to non-smokers and which was found to be statistically significant thereby indicating a reduced para-sympathetic activity.

The expiration: inspiration ratio is based on the sinus arrhythmia during each respiratory cycle, which depends on the variation in the vagal tone. In the present study, a highly significant decrease in the expiration: inspiration ratio was observed in the smokers as compared to that in the non-smokers. G.A. Gould et al., (1986) also found

Table 1: Comparison of mean values of parasympathetic function tests in smokers andnon smokers

Para sympathetic function tests	Smokers(N=25) Mean ± SD	Non-smokers(N=25) Mean ± SD	Z test value	'p' value	Significance
Resting Heart Rate (/min)	84.42 ± 7.86	74.98 ± 8.96	8.41	p<0.01	S
Expiration: Inspiration Ratio	1.23 ± 0.23	1.42 ± 0.21	8.54	p<0.01	S
30:15 Ratio (Response to standing)	0.84 ± 0.25	1.16 ± 0.53	5.0	p<0.01	S
Valsalva Ratio	3.64 ± 1.12	4.76 ± 2.18	8.68	p<0.01	S

Table 2: Comparison of mean values of sympathetic function tests in smokers and non smokers.

Sympathetic function Tests	Smokers(N=25) Mean ± SD	Non-smokers (N=25) Mean ± SD	Z test value	'p' value	Significance
Postural Hypotension Test (Fall in systolic Pressure) (mmHg)	8.87±5.32	8.12±6.47	0.21	p>0.05	NS
Sustained handgrip Test (Rise in diastolic Pressure) (mmHg)	5.23±4.5	10.23±5.23	4.53	p<0.01	S

Table 3: Correlation between smoking index and para sympathetic function tests in smokers

Smoking Index	Resting Heart Rate (/min) Mean ± SD	E : I Ratio Mean ± SD	30:15 Ratio Mean ± SD	Valsalva Ratio Mean ± SD
01-100 (Light smokers) (N=10)	77.29 ± 6.31	1.22 ± 0.09	1.03 ± 0.12	3.66+2.78
101- 200 (Moderate smokers) (N=08)	79.36 ± 2.80	1.08 ± 0.12	0.90 ± 0.06	3.14+2.67
Above 200 (Heavy smokers) (N=7)	81.12 ± 4.26	1.04 ± 0.19	0.93 ± 0.06	1.81+2.47

Table 4: Correlation between smoking index and sympathetic function tests in smokers

Smoking Index	Postural Hypotenstion Test Mean ± SD	Sustained Handgrip Test Mean ± SD
01-100 (Light smokers) (N=10)	7.84 ± 3.49	6.16 ± 3.0
101-200 (Moderate smokers) (N=08)	7.36 ± 3.70	6.18 ± 2.67
Above 200 (Heavy smokers) (N=07)	9.75 ± 2.76	5.87 ± 2.47

statistically highly significant changes in the 30:15 ratio and the expiration: inspiration ratio in smokers as compared to those in the non-smokers.[11]

The valsalva ratio is another reliable indicator of the parasympathetic activity, which is responsible for the recovery of the heart rate after strenuous activities like the Valsalva maneouvre. The manoeuvre creates a high intra-thoracic pressure which evokes a complex circulatory response with four phases. In our study, that smokers had a lower value of the Valsalva ratio as compared to the non-smokers thus indicating a derangement of the parasympathetic function. Other research workers, Mervi et al.,[12] and Beatriz et al.,[13] also found similar results.

In the postural hypotension test, we measured the changes in the degree of the postural hypotension by recording the fall in the systolic blood pressure as an index of the sympathetic activity, and we observed that there were no significant changes in the smokers as compared to those in the non-smokers. It could be possible that in some of these cases, an early involvement of the sympathetic system may be present, which may have not been evident or overt. At the same time, it may be pointed out that the fall in the systolic pressure was greater in the heavy smokers as compared to that in the light smokers, though it was not statistically significant. However, in other studies, significant changes were seen in the postural hypotension test.

In the sustained handgrip test, we measured the rise in the diastolic blood pressure at the point, just before the release of the handgrip. In the present study, it was seen that the rise in the diastolic pressure was significantly less in the smokers as compared to that in the non-smokers thus suggesting a decrease in the sympathetic reactivity. Mervi et al., (1994) also found that the rise in the diastolic pressure was significantly less in the smokers as compared

to that in the non-smokers, thus suggesting a decrease in the sympathetic reactivity. [12]

5. Conclusion

The Resting Heart Rate had significantly increased in case of smokers as compared to non-smokers due to increased sympathetic activity due to release of catecholamines. The Expiration: Inspiration Ratio, 30:15 Ratio (Response to standing) and the Valsalva Ratio had significantly decreased in the smokers as compared to those in the non-smokers due to derangement in parasympathetic activity.

In sustained handgrip test, rise in blood pressure is decreased in smokers as compared to non-smokers due to reduced sympathetic activity.

6. Source of Funding

The project was funded by an institutional research grant from Basaveshwara medical college, Chitradurga.

7. Conflict of Interests

The authors declare that there is no conflict.

Acknowledgements

Authors are grateful to Basaveshwara medical college, Chitradurga for providing facilities to conduct the work.

References

1. Sharma S. New approaches in smoking Cessation. *Indian Heart J*. 2008;60(2):34–7.
2. John RM. Tobacco consumption patterns and it's health implications in India. *Health Policy*. 2005;71(2):213–22.
3. Bansal S, Bansal A. Effect of Age and Sex on the R-R interval in ECG of Healthy Individuals. *Indian J Basic Appl Med Res*. 2012;1(3):178–84.
4. Laustiola KE, Lassila R, Kaprio J, Koskenvuo M. Decreased beta-adrenergic receptor density and catecholamine response in male cigarette smokers. A study of monozygotic twin pairs discordant for smoking. *Circulation*. 1988;78(5):1234–40. doi:10.1161/01.cir.78.5.1234.
5. Akselrod S, Gordon D, Madwed JB, Snidman NC, Shannon DC, Cohen RJ. Hemodynamic regulation: investigation by spectral analysis. *Am J Physiol*. 1985;249(4 Pt 2):H867–75.
6. Saul JP, Berger RD, Chen MH, Cohen RJ. Transfer function analysis of autonomic regulation. II. Respiratory sinus arrhythmia. *Am J Physiol* . 1989;256(1 Pt 2):H153–61.
7. Gupta SK. Respiratory disorders among workers in a railway workshop. *Indian J Tuberc*. 1995;42:161.
8. Kamble PH, Rode MV, Phatak MS, Tayade P. Is Smokeless Tobacco using a risk factor for Coronary artery disease? A comparative study of smokers and smokeless tobacco users. *Indian J Basic Appl Med Res*. 2011;1(1):22–30.
9. Ambrose JA, Barua RS. The pathophysiology of cigarette smoking and cardiovascular disease. *J Am Coll Cardiol*. 2004;43(10):1731–7. doi:10.1016/j.jacc.2003.12.047.
10. Health effects of Tobacco. Available from: www.wikipedia.org/wiki/effectsoftobacco.
11. Diaz A, Bourassa G, Guertin MC. Jean-Claude Tardif 1 Long-term prognostic value of resting heart rate in patients with suspected or proven coronary artery disease. *Eur Heart J*. 2005;26(10):967–74.
12. Gould GA, Ashworth M, Lewis GT. Are cardiovascular reflexes more commonly impaired in patients with bronchial carcinoma? *Thorax*. 1986;41(5):372–75. doi:10.1136/thx.41.5.372.
13. Kotamäki M. Smoking induced differences in autonomic responses in military pilot candidates. *Clin Autonomic Res*. 1995;5(1):31–6. doi:10.1007/bf01845496.

Author biography

Tejashwini Basarigidad, Associate Professor

Ganashree C P, Professor

Cite this article: Basarigidad T, Ganashree C P. The effect of smoking on the cardiovascular autonomic functions tests. *Indian J Clin Anat Physiol* 2021;8(1):69-73.