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Original Research Article

Effect of Smoking on Cardiovascular Autonomic Function Tests

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Abstract

Introduction: Cigarette smoking is a prime risk factor for cardiovascular morbidity and mortality. Chronic smoking results in autonomic dysfunction leading to increased cardiovascular risk in smokers. The current study was aimed to evaluate the cardiovascular autonomic function in smokers.

Materials and Methods: 50 male subjects in the age group 25 years to 45 years comprising of 25 smokers and 25 nonsmokers as control group were selected for present study. The fifty study and control subjects were subjected to a battery of cardiac autonomic function tests

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. 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 significant difference between the mean values of the Postural hypotension test and that there was a significant difference between the mean values of the Sustained handgrip test in the smokers and the non-smokers

Conclusion: The cardiovascular autonomic function tests are reliable non-invasive and easy to carry out. By using these simple tests we can detect the early involvement of the autonomic nervous system before the clinical symptoms appear. This study indicates that smoking has adverse effect on cardiovascular autonomic functions.

Keywords: cardiovascular autonomic function tests, smoking, blood pressure, Heart rate

Introduction

One of the main global causes of preventable morbidity and mortality is tobacco use .[1] According to the World Health Organization, 100 million people died globally from tobacco use in the 20th century. [2]Tobacco-related deaths would reach around 100 million annually by the early 2030s. [3] Atherosclerosis [4], coronary heart disease [5], acute myocardial infarction [6], and sudden cardiac death are all significantly increased by cigarette smoking. [7-8]. Reducing cardiovascular mortality and morbidity is linked to quitting smoking.[9].

The autonomic nervous system is essential for controlling cardiovascular activity,[10] and the effective regulation of the cardiovascular system depends on the balance between the two parts of the system—the parasympathetic and sympathetic nervous systems. [11,12, 13]

The Autonomic Nervous System malfunctions as a result of prolonged smoking. [14] Smokers have an elevated risk of cardiovascular disease due to autonomic changes. Smoking is linked to a noticeable and sustained rise in blood pressure and heart rate. [15] Human baroreflex sensitivity is diminished by smoking, which causes pressor and tachycardial effects in smokers as well as a corresponding change in variability. [16] Smoking, in particular, acts on peripheral sympathetic sites, raising catecholamine levels in the blood, enhancing sympathetic outflow, and causing a sustained decrease in vagal drive. [17]

In a clinical setting, the sympathetic and parasympathetic divisions of cardiovascular autonomic regulation can be determined using straightforward, non-invasive techniques known as classical autonomic function tests.[18,19] For this reason, the current cross-sectional study was conducted to compare the effects of smoking on cardiovascular autonomic function test among smokers and nonsmokers.

Materials and Methods:

The current investigation was conducted in the Physiology Department, Government Medical

college, Ongole, Andhra Pradesh, India during September 2022 to February 2023, and the institutional ethics committee gave it their approval. For this study, a control group of fifty male individuals, aged between 25 and 45, was chosen, consisting of 25 smokers and 25 non-smokers. The patients from the regular OPD and staff members were chosen as the participating subjects.

Criteria for Inclusion and Exclusion:

A persistent smoker with at least five pack years is the case group.(Pack year = daily pack count x number of years; one pack contains 20 cigarettes). Additionally, participants having a history of significant illnesses such as peripheral neuropathy, diabetes mellitus, or hypertension were not allowed to participate in this study.

The subjects in the control group for this study were those who had never smoked in their lives and who did not suffer from any other tobacco-related addiction. Exclusion from the current study was granted to patients with a history of significant illnesses, such as peripheral neuropathy, diabetes mellitus, or hypertension, either in the past or present.

Every participant was made aware of the study and given the opportunity to provide signed, informed consent. All of the chosen individuals were invited to the Department of Physiology's Research Laboratory by 8:30 a.m. The participants were told not to eat anything before arriving, and they were not to engage in any physical activity or smoke or drink tea or coffee the night before. Every test was carried out in a calm and cold environment, with room temperature ranging from 27°C to 30°C, between 8.30 and 11:00 in the morning. The participants were instructed to unwind in the laboratory while lying supine for thirty minutes; tests weren't conducted until the subjects were completely at ease both physically and mentally. Every participant had their physical anthropometry, as well as a number of physiological and autonomic function characteristics, recorded.

The study and control groups' participants' anthropometric measurements included the following: I. Height (centimeters): This was measured to the closest 0.1 cm while the individual was standing without shoes; (ii) weight (in kg): The subjects were weighed in a standardized apparatus using the least amount of clothing, to the closest 0.1 kg; (iii) body mass index (kg/m2): Based on each participant's weight and height, this was computed.

Cardiac Autonomic Functions Tests:

Parasympathetic function tests:

1. Expiration –Inspiration ratio (E: I ratio): The participant was instructed to inhale deeply for five seconds, then exhale deeply for five seconds. Three similar cycles of the ECG were recorded. The basis of this test is sinus arrhythmia, which is dependent on vagal tone change throughout each respiratory cycle.

$$\text{E/I Ratio} = \frac{\text{Longest RR interval during expiration}}{\text{Shortest RR interval during inspiration}}$$

2. **30:15 ratio : (Response to standing):** Subject was asked to lie down comfortably over the couch ,then he was asked to stand up. The heart rate was measured at the 15th and 30th beats after standing.

$$\text{30:15 ratio} = \frac{\text{Duration of longest R-R interval around 30th beat}}{\text{Duration of shortest R-R interval around 15th beat}}$$

3. **Valsalva ratio:** The subject was instructed to sit comfortably. At rest, the heart rate was measured using an ECG. A nose clip was used to clip the subject's nose, and a mouth piece was put between the subject's teeth and lips. The mouthpiece's opposite end was linked to a mercury manometer. The subject was instructed to blow air into the mouthpiece while maintaining a pressure of 40 mmHg for 15 seconds. The ECG was regularly monitored.

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

Sympathetic Function Tests

1. The Orthostatic standing Test: The individuals were advised to lie comfortably supine for 15 minutes while their blood pressures were taken. They were then instructed to stand up, and their blood pressures were taken both immediately and one minute later. The difference in these two measurements was observed due to a drop in SBP when standing.

2. The Isometric Handgrip Test: The individual was instructed to sit and relax in a chair. To assess grip strength, subjects were instructed to hold a handgrip dynamometer with their dominant hand and apply maximum force for a few seconds. His maximum voluntary contraction (MVC) was determined by taking the highest value of three identical contractions. On the handgrip dynamometer, the subject was asked to exert 30% of MVC for 5 minutes using the dominant arm. At rest and at 1 minute intervals during the maneuver, blood pressure was monitored in the non-exercising arm.

The data was tabulated and statistical analysis was done by using SPSS ,Version 16. Comparison between two groups was done by using unpaired t test. P value was calculated.

P vaule <0.05 was considered significant.

Results:

Anthropometric parameters were recorded in both groups of participants and are shown in Table 1. In all anthropometric measurements, there is no significant difference between the control and study groups.

Table 1: Comparison of Age & BMI between control and smokers

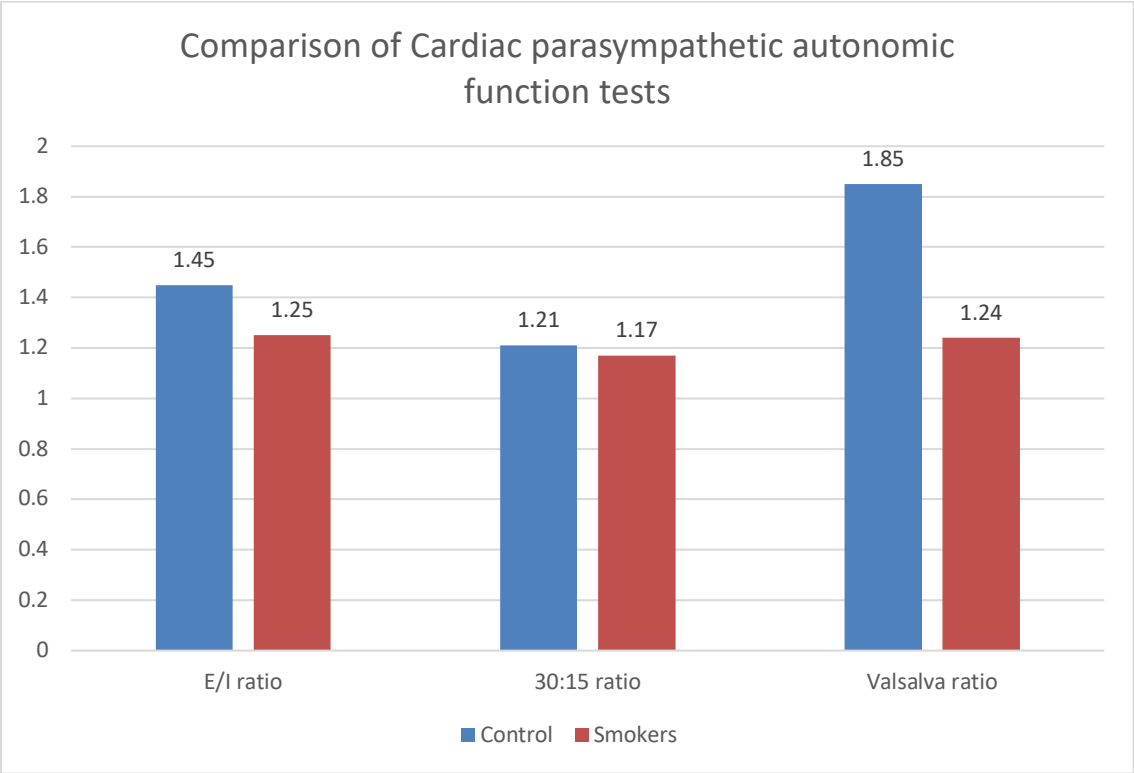
Variable	Control (mean ± SD)	Smokers 3(mean ± SD)	P value
Age	34.98 ± 2.85	33.47 ± 2.54	0.324
BMI	23.98± 2.23	23.04± 2.12	0.254

Table 2 demonstrates that there was a statistically significant difference in the E/I ratio, Valsalva ratio, and 30/15 ratio between controls and smokers. There was a significant difference in the mean values of the isometric hand grip test and the orthostatic hypotension test between smokers and controls (P 0.001). (Graph 1 & 2)

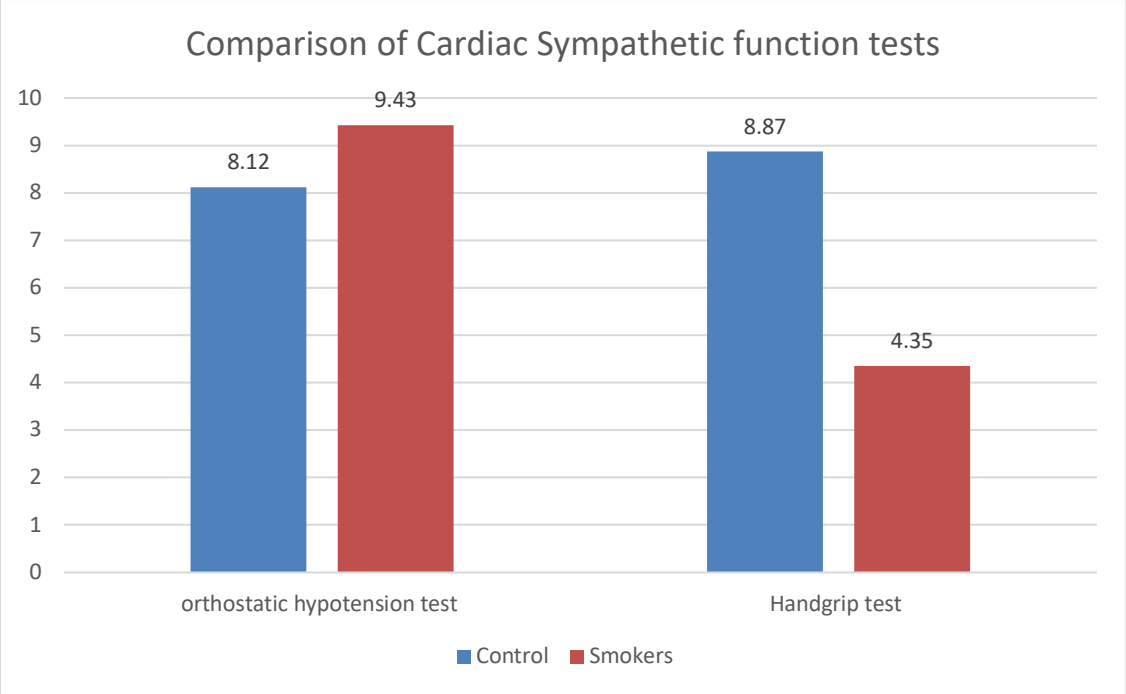
Table 2: Comparison of cardiac autonomic function tests between control and smokers

Variable	Control (mean ± SD)	Smokers (mean ± SD)	P value
E/I ratio	1.45 ± 0.19	1.25 ±0.21	0.001*
30:15 ratio	1.21 ± 0.53	1.17 ± 0.34	0.02*
Valsalva ratio	1.85 ± 0.23	1.24 ± 0.24	0.003*
Orthostatic hypotension test (Fall in Systolic blood pressure) (mmHg)	8.12±6.47	8.87±5.32	0.002*
Handgrip test (Rise in Diastolic blood pressure) (mmHg)	9.43±5.23	4.35±4.5	0.01*

*Significant



Graph 1: Comparison of cardiac parasympathetic function tests



Graph 2: Comparison of cardiac Sympathetic function tests

Discussion:

Cigarette smoke contains about 4000 chemicals, such as nicotine, carbon monoxide, and oxidative gasses, that are detrimental to cardiovascular health. Nicotine promotes coronary and peripheral vasoconstriction, increases sympathetic activity, elevates heart rate, and modifies cardiac autonomic function. enhanced workload on the heart and increased release of catecholamines.[19] Smoking causes the sympathetic nervous system to become activated, and this is dependent on an increase in catecholamine release. Smoking impairs the baroreflex, and the pressor response is also caused by a partial incapacity to reflexively offset the effects of sympathetic activation. [20]

One measure that can be used to gauge how responsive the parasympathetic nervous system is the heart rate response to standing, or the 30:15 ratio. A drop in the 30:15 ratio between smokers and non-smokers was found to be statistically significant in the current study, suggesting a decrease in parasympathetic activity. The sinus arrhythmia that occurs throughout each respiratory cycle—which is dependent on variations in vagal tone—is the basis for the expiration: inspiration ratio. [21]

In this study, smokers' expiration: inspiration ratios were significantly lower than non-smokers' in relation to each other. Additionally, compared to non-smokers, G.A. Gould et al. discovered statistically significant differences in the 30:15 ratio and the expiration: inspiration ratio in smokers [22].

Another trustworthy measure of parasympathetic activity, which is in charge of restoring heart rate following taxing exercises like the Valsalva maneouvre, is the valsalva ratio. The maneuver produces a high intra-thoracic pressure, which sets off a four-phase complicated circulatory response. According to our research, smokers' Valsalva ratios were lower than those of non-smokers', suggesting a disruption in the parasympathetic nervous system. Comparable findings were also discovered by other researchers, Mervi et al. [23] and Beatriz et al. [24].

In the postural hypotension test, we measured changes in the degree of postural hypotension by recording the fall in systolic blood pressure as an index of sympathetic activity, and we found significant differences between smokers and non-smokers. Smokers' systolic blood pressure dropped more than that of non-smokers', indicating a reduction in sympathetic reactivity. Motilal C. Tayade et colleagues. noted a comparable decrease in systolic blood pressure in heavy smokers. [25].

We measured the rise in diastolic blood pressure right before the handgrip was released in the sustained handgrip test. The current study's findings indicate a decrease in sympathetic reactivity because the smokers' rise in diastolic pressure was noticeably lower than that of the non-smokers. Additionally, Mervi et al. observed that smokers' diastolic pressure rose noticeably less than non-smokers' did, indicating a reduction in sympathetic reactivity [23].

Conclusion:

The cardiovascular autonomic function tests are safe, non-invasive, and simple to do. We can detect early involvement of the autonomic nervous system before clinical symptoms develop by employing

these basic procedures. Smokers have a distinct sympathovagal imbalance, which manifests as sympathetic over activity and parasympathetic withdrawal. The battery of autonomic function tests is an efficient technique for detecting autonomic impairment early on. As a result, we infer that cigarette smoking has an effect on both the parasympathetic and sympathetic nervous systems.

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