



A Cross-Sectional Study to Assess the Correlation between Smoking and Heart Rate Variability in Rural Population of Meerut

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(Received: 16 February 2026

Revised: 25 March 2026

Accepted: 10 April 2026)

KEYWORDS

Smoking, Heart Rate Variability, Rural Population, Autonomic Nervous System, LF/HF Ratio

ABSTRACT:

Background: Tobacco smoking is a major modifiable risk factor contributing to cardiovascular morbidity through its influence on autonomic regulation. Heart rate variability (HRV) is a reliable, non-invasive indicator of autonomic nervous system function.

Aims and Objectives: To assess the impact of smoking on HRV in rural population of Meerut.

Materials and Methods: A cross-sectional study was conducted on 100 participants (50 smokers and 50 non-smokers) aged 18–60 years from rural population of Meerut. Participants were categorized into ≤ 30 years and > 30 years age groups. HRV was recorded using a standardized protocol, and both time-domain and frequency-domain parameters were analyzed. Statistical comparison was performed using Student's unpaired t-test.

Results: In the ≤ 30 -year age group, smokers exhibited significantly higher LF and LF/HF ratio along with reduced HF values. Similar statistically significant alterations were observed in the > 30 -year age group, indicating persistent autonomic imbalance among smokers.

Conclusion: Smoking is associated with early and sustained impairment of autonomic function in rural populations, characterized by sympathetic predominance and reduced parasympathetic activity.

Introduction

Tobacco use remains a leading cause of preventable morbidity and mortality worldwide, particularly due to its strong association with cardiovascular diseases. A substantial proportion of tobacco-related deaths occur in low- and middle-income countries, including India [1]. National survey data indicate that tobacco consumption is more prevalent in rural populations compared to urban areas [2].

The adverse cardiovascular effects of smoking are mediated through multiple mechanisms, including oxidative stress, endothelial dysfunction, and disruption of autonomic nervous system (ANS) balance [3]. One of the most sensitive tools for assessing autonomic function is heart rate variability (HRV), which reflects beat-to-beat variations in cardiac rhythm [4].

Reduced HRV is indicative of decreased parasympathetic activity and/or increased sympathetic drive, both of which are associated with elevated cardiovascular risk. Rural populations may be particularly vulnerable due to higher tobacco use, limited awareness, and reduced access to healthcare services [5].

Despite this, limited data are available regarding the impact of smoking on autonomic function in rural

populations. Therefore, the present study was undertaken to assess the effect of smoking on HRV in the rural population of Meerut.

Materials and Methods

Study Design

This cross-sectional observational study was conducted in the Department of Physiology in collaboration with the Department of Medicine at LLRM Medical College, Meerut, over a period of 12 months. Ethical approval was obtained from the Institutional Ethics Committee.

Study Population

A total of 100 male participants (50 smokers and 50 non-smokers), aged 18–60 years, were recruited from rural areas of Meerut district based on census data (2011).

Inclusion Criteria

Male participants aged 18–60 years
Apparently healthy individuals

Exclusion Criteria

Participants with:
Hypertension, diabetes mellitus



Cardiovascular, respiratory, neurological, or endocrine disorders

Alcohol dependence

Use of drugs affecting autonomic function

Study Protocol

Participants were instructed to avoid caffeine, alcohol, heavy meals, and strenuous physical activity prior to testing. After adequate rest in a thermoneutral environment, baseline cardiovascular parameters were recorded.

A 5-minute resting ECG was recorded in the supine position using a standardized data acquisition system (Physiopac). HRV analysis was performed using Kubios HRV software following standard guidelines.

Tables

Table 1: Comparison of Cardiovascular Parameters between Rural Smokers and Rural Non smokers (≤30 year age)

Parameters	Smokers(n=20) Mean±SD	Non smokers(n=23) Mean±SD	p Value
SBP(mm Hg)	116.2±8.85	116±7.86	0.937814
DBP(mm Hg)	78.6±4.90	78.26±4.95	0.822994
Resting HR(beats per min)	76.85±8.68	75.39±7.34	0.553754
* p Value<0.05 significant			

Table 2: Comparison of HRV Parameters between Rural smokers and Rural Non smokers (≤30 year age)

Parameters	Smokers(n=20) Mean±SD	Non smokers(n=23) Mean±SD	p Value
Mean HR(1/min)	51.58±6.72	47.68±6.72	0.064514
Mean RR interval(s)	1.2±0.14	1.29±0.2	0.113819
RMSSD(ms)	53.1±42.36	54.43±38.95	0.914824
NN50(count)	25.75±10.78	25.83±9.16	0.980158
pNN50(%)	10.5±4.68	11.62±3.93	0.401548
LF(n.u.)	83.04±6.89	71.83±8.71	0.000037 *
HF(n.u.)	8.68±3.24	16.46±8.85	0.000603 *
LF/HF ratio	10.79±3.73	6.08±3.79	0.000193 *

Parameters Assessed

Time-domain: Mean HR, Mean RR interval, RMSSD, NN50, pNN50

Frequency-domain: LF, HF, LF/HF ratio

Statistical Analysis

Data were analyzed using Student's unpaired t-test. Results were expressed as mean ± standard deviation. A p-value <0.05 was considered statistically significant.

Results

A total of 100 participants were included and categorized into ≤30 years and >30 years age groups.



* p Value<0.05 significant			
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Table 3: Comparison of Cardiovascular Parameters between Rural Smokers and Rural Non smokers (>30 year age)

Parameters	Smokers(n=30) Mean±SD	Non smokers(n=27) Mean±SD	p Value
SBP(mm Hg)	122.87±8.16	122.3±9.59	0.80928
DBP(mm Hg)	80.53±6.74	80.44±6.48	0.959813
Resting HR(beats per min)	78.9±5.98	76.44±7.61	0.1789921
* p Value<0.05 significant			

Table 4: Comparison of HRV Parameters between Rural Smokers and Rural non smokers (>30 year age)

Parameters	Smokers(n=30) Mean±SD	Non smokers(n=27) Mean±SD	p Value
Mean HR(1/min)	46.2±6.53	48.13±5.88	0.246983
Mean RR interval(s)	1.32±0.2	1.27±0.14	0.295884
RMSSD(ms)	36.03±23.68	54.82±51.71	0.07829
NN50(count)	20.57±12.68	16.81±9.98	0.223286
pNN50(%)	9.18±5.85	7.42±4.29	0.204654
LF(n.u.)	79.67±10.17	72.81±8.71	0.008684 *
HF(n.u.)	12.08±7.78	18.36±6.24	0.001532 *
LF/HF ratio	9.97±6.21	4.74±2.60	0.000156 *
* p Value<0.05 significant			

No statistically significant differences were observed in systolic blood pressure (SBP), diastolic blood pressure (DBP), or resting heart rate between smokers and non-smokers in either age group (**Table 1 and Table 3**).

In the ≤30-year age group, smokers demonstrated significantly higher LF and LF/HF ratio along with significantly lower HF compared to non-smokers (**Table 2**).

Similarly, in the >30-year age group, smokers exhibited significantly higher LF, lower HF, and elevated LF/HF ratio (**Table 4**).

These findings indicate a consistent pattern of sympathetic dominance and reduced parasympathetic activity among smokers across both age groups.

Discussion

The present study demonstrates significant alterations in cardiac autonomic regulation among rural smokers, as reflected by changes in HRV parameters. The increase in LF and LF/HF ratio along with reduced HF suggests a shift toward sympathetic predominance and reduced parasympathetic activity.



Nicotine plays a central role in this autonomic imbalance by stimulating catecholamine release through activation of the sympathetic nervous system, leading to increased heart rate, vasoconstriction, and elevated cardiovascular workload [3]. Additionally, smoking impairs baroreceptor sensitivity and endothelial function, further contributing to autonomic dysfunction.

The findings of this study are consistent with previous research demonstrating reduced vagal tone and increased sympathetic activity in smokers [6,7]. The presence of significant HRV changes in younger individuals indicates that autonomic dysfunction develops early, even before the onset of clinically detectable cardiovascular abnormalities.

The absence of significant differences in conventional cardiovascular parameters such as blood pressure and resting heart rate suggests that HRV is a more sensitive indicator of early cardiovascular risk.

Unlike some urban-based studies, this study shows persistent autonomic imbalance across both age groups, which may be attributed to higher tobacco exposure, use of unfiltered tobacco products, and socioeconomic factors in rural populations [5,8].

Rural populations are particularly vulnerable due to higher prevalence of tobacco use, lower awareness, and limited healthcare access. These findings highlight the importance of early screening and targeted public health interventions in rural settings.

However, the cross-sectional design limits causal inference, and inclusion of only male participants restricts generalization. Future longitudinal studies are required to evaluate the reversibility of HRV changes following smoking cessation.

Conclusion

Smoking is associated with significant impairment of autonomic function in rural populations, characterized by increased sympathetic activity and reduced parasympathetic tone. These changes are evident even in younger individuals and may precede overt cardiovascular disease.

HRV analysis can serve as an effective non-invasive tool for early identification of cardiovascular risk in smokers, particularly in rural settings.

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