

Evaluation of sympathetic and parasympathetic cardiovascular autonomic function in healthy subjects and patients with type 2 diabetes mellitus

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Abstract: *Background:* Diabetic autonomic neuropathy is a common yet under diagnosed complication of diabetes mellitus, with cardiovascular involvement contributing substantially to morbidity and mortality. Assessment of cardiovascular autonomic function using non-invasive tests facilitates early identification of autonomic dysfunction. In addition, age-related variations in autonomic function among healthy individuals warrant evaluation. *Objectives:* To evaluate cardiovascular autonomic function in healthy subjects across different age groups; to assess the presence of autonomic neuropathy in patients with type 2 diabetes mellitus; and to determine the most sensitive sympathetic and parasympathetic autonomic function tests. *Methods:* A cross-sectional comparative study was conducted in the Department of Physiology, Al-Ameen Medical College Hospital and Government District Hospital, Bijapur. Healthy subjects of both sexes were categorized into four age groups (<20, 21–30, 31–40 and 41–50 years). Patients with diagnosed type 2 diabetes mellitus constituted the diabetic group. Cardiovascular autonomic function was assessed using three sympathetic tests (blood pressure response to standing, sustained handgrip and cold pressor test) and three parasympathetic tests (heart rate response to standing, deep breathing and Valsalva manoeuvre). Data were analysed using appropriate parametric tests and coefficient of variation to assess test sensitivity. *Results:* Cardiovascular autonomic function did not differ significantly across age groups among healthy subjects. Diabetic patients demonstrated a higher prevalence of autonomic dysfunction, with predominant impairment of parasympathetic function. Among parasympathetic tests, the heart rate response to standing (30:15 ratio) showed the lowest coefficient of variation, indicating the highest sensitivity. *Conclusion:* Cardiovascular autonomic function remains preserved in healthy individuals across different age groups but is significantly impaired in patients with type 2 diabetes mellitus. Parasympathetic dysfunction predominates in diabetic autonomic neuropathy. A combination of autonomic function tests is recommended for early detection rather than reliance on a single test.

Keywords: Cardiovascular autonomic function, Diabetes mellitus, Autonomic neuropathy, Sympathetic tests, Parasympathetic tests.

Introduction

Diabetes mellitus is a major global health problem associated with a wide range of chronic complications, among which neuropathies are particularly common. Autonomic neuropathy represents one of the most serious forms of diabetic neuropathy, often remaining asymptomatic in its early stages. Cardiovascular autonomic neuropathy is clinically important because it is associated with resting tachycardia, orthostatic hypotension, exercise intolerance, silent myocardial ischemia and an increased risk

of sudden cardiac death. Assessment of cardiovascular autonomic function is essential for early detection of autonomic involvement [1-2]. Cardiovascular reflex tests provide a simple, noninvasive and reliable method for evaluating sympathetic and parasympathetic components of the autonomic nervous system [3-4].

However, no single test is sufficient to detect all forms of autonomic dysfunction. Furthermore, limited data are available regarding age-related changes in

cardiovascular autonomic function among healthy individuals, particularly in the Indian population. The present study was undertaken to evaluate cardiovascular autonomic function in healthy subjects of different age groups and to assess autonomic dysfunction in patients with type 2 diabetes mellitus [5]. Cardiovascular autonomic function remains largely preserved across different age groups in healthy individuals [6].

The study also aimed to identify the most sensitive autonomic function tests for early detection of diabetic autonomic neuropathy.

Objectives:

1. To assess cardiovascular autonomic function in healthy subjects of different age groups.
2. To evaluate autonomic neuropathy in patients with type 2 diabetes mellitus for early detection.
3. To identify the most sensitive sympathetic and parasympathetic cardiovascular autonomic function tests.

Material and Methods

Study Design: Cross-sectional comparative study.

Study Setting: Department of Physiology, Al-Ameen Medical College Hospital and Government District Hospital, Bijapur.

Ethical Considerations: The study was approved by the Institutional Ethics Committee. Written informed consent was obtained from all participants prior to enrolment.

Study Population:

- *Healthy subjects:* Individuals of both sexes divided into four age groups: <20, 21–30, 31–40 and 41–50 years.
- *Diabetic group:* Patients with diagnosed type 2 diabetes mellitus.

Sampling Technique: Convenience sampling was used to recruit eligible participants attending the outpatient departments during the study period.

Inclusion Criteria:

- Healthy subjects without a history of diabetes, cardiovascular, neurological or endocrine disorders.
- Patients with diagnosed type 2 diabetes mellitus.

Exclusion Criteria:

- History of cardiovascular disease, hypertension, neurological disorders or endocrine disorders other than diabetes.
- Use of medications known to affect autonomic function.

Assessment of Autonomic Function: Cardiovascular autonomic function was evaluated using six standard non-invasive tests.

Sympathetic function tests:

1. Blood pressure response to standing
2. Blood pressure response to sustained handgrip
3. Blood pressure response to cold pressor test

Parasympathetic function tests:

1. Heart rate response to standing (30:15 ratio)
2. Heart rate response to deep breathing
3. Heart rate response to Valsalva manoeuvre

Statistical Analysis: Data were expressed as mean \pm standard error of mean (SEM). Paired and unpaired t-tests were used for intra-group and inter-group comparisons. The coefficient of variation was calculated to determine the sensitivity of autonomic function tests. A p value <0.05 was considered statistically significant.

Results

Table no 1 revealed that the resting pulse rate did not show marked variation among the healthy groups and was comparable to that observed in diabetic patients. Systolic and diastolic blood pressure values were relatively similar across the healthy age groups; however, diabetic subjects exhibited higher mean systolic (136.2 ± 3.03 mmHg) and diastolic blood pressure (83.2 ± 1.93 mmHg) compared to healthy controls. Body temperature remained within the normal physiological range in all groups, with no appreciable inter group variation.

Table-1: Baseline Characteristics of Study Subjects

Group	n	Age (years) Mean ± SEM	Resting Pulse Rate (bpm) Mean ± SEM	SBP (mmHg) Mean ± SEM	DBP (mmHg) Mean ± SEM	Body Temperature (°F) Mean ± SEM
Group I (<20 yrs)	16	18.2 ± 0.20	78.5 ± 2.45	112.1± 2.94	66.9± 1.98	96.9± 0.29
Group II (21–30 yrs)	17	27.3 ± 0.51	77.7± 2.25	109.6 ± 2.19	67.1 ± 1.66	96.2 ± 0.54
Group III (31–40 yrs)	13	36.7 ± 0.90	74.2± 1.14	108.2 ± 3.44	72.3 ± 3.02	96.8± 0.14
Group IV (41–50 yrs)	10	43.1 ± 0.50	78.8± 1.76	114.4 ± 3.97	74.0 ± 3.05	96.9± 0.14
Group V (Diabetics)	31	52.6 ± 2.34	79.4± 1.10	136.2 ± 3.03	83.2 ± 1.93	96.4± 0.68

Table 2 depicts the blood pressure response to standing among healthy subjects and diabetic patients. In all groups, a significant fall in systolic blood pressure was observed one minute after standing when compared to the supine position

($p < 0.05$). This postural decline in systolic blood pressure was consistent across all healthy age groups as well as in the diabetic group.

Table-2: Blood Pressure Response to Standing

Group	SBP				Result	DBP				Result
	Lying		After 1min Standing			Lying		After 1min Standing		
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
Group I	112.1	2.9	104.5	3.12	S	66.8	1.98	71.2	2.86	S
Group II	109.6	2.2	97.5	2.85	S	67.1	1.66	70.0	2.84	NS
Group III	108.1	3.5	95.3	2.99	S	72.3	3.02	70.7	2.87	NS
Group IV	114.4	3.9	102.6	4.25	S	74.0	3.05	68.2	7.069	NS
Group V	136.4	3.0	128.3	3.22	S	83.2	1.93	86.1	1.83	S

* $p < 0.05$ compared to lying position

Table no 3 showed that the diastolic blood pressure demonstrated a significant increase in response to sustained handgrip across all healthy age groups as well as in the diabetic group. The magnitude of increase in both systolic and diastolic blood pressure was higher in diabetic subjects compared to healthy controls, indicating

an exaggerated sympathetic response during sustained isometric exercise. These findings suggest preserved sympathetic cardiovascular reactivity in healthy individuals, while diabetic patients exhibit altered autonomic regulation as reflected by greater pressor responses to sustained handgrip.

Table-3: Blood Pressure Response to Sustained Handgrip (5th Minute)

Group	SBP				Result	DBP				Result
	At Rest		At 5min			At rest		At 5 Min		
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
G-I	111.5	2.9	135.8	4.0	S	66.9	1.98	101.8	3.6	S
G-II	109.6	2.2	134.0	3.5	S	67.1	1.70	100.8	2.8	S
G-III	108.2	3.4	137.2	3.4	S	72.3	3.02	101.8	3.7	S
G-IV	114.4	3.9	143.8	5.7	S	74.0	3.05	104.6	3.2	S
G-V	136.4	3.0	166.1	3.5	S	83.2	1.9	115.2	1.9	S

* $p < 0.001$ compared to resting values

Table no 4 showed that the, significant rise in diastolic blood pressure was observed following the cold pressor test across all healthy age groups as well as in the diabetic group. The pressor response was more pronounced in diabetic patients, reflecting enhanced sympathetic activation in response to cold stress. These

findings indicate intact sympathetic vasoconstrictor responses in healthy individuals and altered autonomic regulation in diabetic subjects, as evidenced by greater elevations in both systolic and diastolic blood pressure during the cold pressor test.

Table-4: Blood Pressure Response to Cold Pressor Test

Group	SBP				Result	DBP				Result
	Before		After			Before		After		
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
G-I	112.1	2.9	118.1	3.9	S	66.9	1.9	73.4	2.4	S
G-II	109.6	2.2	109.6	2.2	S	67.1	1.7	77.9	2.4	S
G-III	108.2	3.4	116.6	4.3	S	72.3	3.0	80.0	2.8	S
G-IV	114.4	3.9	121.8	3.8	S	74.0	3.1	82.0	3.3	S
G-V	136.4	3.0	142.9	3.3	S	83.2	1.9	87.7	2.0	S

Table 5 presents the parasympathetic autonomic function test results among healthy subjects and diabetic patients. The heart rate response to standing, expressed as the 30:15 ratio, remained within normal limits and showed no significant variation across the healthy age groups. However, a significant reduction in the 30:15 ratio was observed in diabetic subjects when compared to healthy controls ($p < 0.05$), indicating impaired parasympathetic function. Heart rate response to

deep breathing demonstrated a progressive decline with increasing age among healthy subjects, with a statistically significant reduction observed in Groups III and IV when compared to Group I ($p < 0.05$). Diabetic patients showed a marked reduction in heart rate variability during deep breathing, suggesting significant parasympathetic dysfunction.

Table-5: Parasympathetic Autonomic Function Tests

Group	30:15 Ratio (Mean ± SEM)	HR Response to Deep Breathing (bpm)	Valsalva Ratio
Group-I	1.34 ± 0.003	26.50 ± 2.38	1.41 ± 0.007
Group-II	1.34 ± 0.004	21.10 ± 1.50	1.70 ± 0.11
Group-III	1.31 ± 0.003	19.40 ± 1.74*	1.57 ± 0.009
Group-IV	1.34 ± 0.004	18.08 ± 1.44*	1.86 ± 0.13
Group-V	1.12 ± 0.0016*	13.20 ± 0.97*	1.41 ± 0.006

* $p < 0.05$ compared to Group I

Discussion

The present study demonstrates that cardiovascular autonomic function remains largely preserved across different age groups in healthy individuals [6]. This finding suggests that within the studied age range, aging alone does not significantly compromise autonomic cardiovascular regulation. These observations are in agreement with earlier reports indicating minimal age-related autonomic decline in the absence of systemic disease.

In contrast, patients with type 2 diabetes mellitus exhibited significant impairment of cardiovascular autonomic function, with predominant involvement of the parasympathetic component [7-8]. Early parasympathetic dysfunction in diabetic autonomic neuropathy has been widely reported and is attributed to the greater vulnerability of longer vagal fibers to metabolic and ischemic injury [9-11]. Among the parasympathetic tests, the heart rate

response to standing showed the lowest coefficient of variation, indicating superior sensitivity for detecting autonomic dysfunction. Sympathetic tests demonstrated comparable sensitivity, emphasizing that reliance on a single test may lead to under-diagnosis. The findings highlight the importance of employing a battery of autonomic function tests for comprehensive assessment.

Conclusion

Cardiovascular autonomic function does not show significant age-related deterioration among healthy individuals but is markedly impaired in patients with type 2 diabetes mellitus. Parasympathetic dysfunction predominates in diabetic autonomic neuropathy. No single autonomic function test is sufficient for diagnosis; therefore, a combination of sympathetic and parasympathetic tests is

recommended for early detection and evaluation of cardiovascular autonomic dysfunction in diabetes mellitus.

Sensitivity analysis of autonomic function tests based on coefficient of variation revealed that among parasympathetic tests, heart rate response to standing (30:15 ratio) showed the lowest coefficient of variation (0.71%), indicating it to be the most sensitive test for detecting parasympathetic dysfunction in diabetic patients. Heart rate response to deep breathing and the Valsalva manoeuvre demonstrated moderate sensitivity [12-15]. All sympathetic tests, including blood pressure response to standing, sustained handgrip, and cold pressor test, showed comparable coefficients of variation, suggesting similar sensitivity among these tests.

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References

1. Pop-Busui R, Boulton AJM, Feldman EL et al. Diabetic neuropathy: A position statement by the American Diabetes Association. *Diabetes Care*. 2017; 40(1):136-154.
2. Spallone V, Ziegler D, Freeman R et al. Cardiovascular autonomic neuropathy in diabetes: Clinical impact, assessment, diagnosis and management. *Diabetes Metab Res Rev*. 2019; 35(1):e3151.
3. Agashe S, Petak S. Cardiac autonomic neuropathy in diabetes mellitus. *Methodist De Bakey Cardiovasc J*. 2018; 14(4):251-256.
4. Benichou T, Pereira B, Mermillod M et al. Heart rate variability in type 2 diabetes mellitus: A systematic review. *PLoS One*. 2018; 13(4):e0195166.
5. Ziegler D, Strom A, Knebel B et al. Cardiovascular autonomic neuropathy: Clinical manifestations and measurement. *Diabetologia*. 2021; 64(8):1687-1700.
6. Serhiyenko V, Serhiyenko A. Cardiac autonomic neuropathy: Risk factors, diagnosis and treatment. *World J Diabetes*. 2018; 9(1):1-24.
7. Pop-Busui R. Cardiac autonomic neuropathy in diabetes: A clinical perspective. *Diabetes Care*. 2020; 43(3):434-441.
8. Tesfaye S, Selvarajah D. Advances in the epidemiology, pathogenesis and management of diabetic neuropathy. *Diabetes Metab Res Rev*. 2019; 35(1):e3146.
9. Kempler P, Amarenco G, Freeman R et al. Management strategies for cardiovascular autonomic neuropathy. *Clin Auton Res*. 2020; 30(2):93-105.
10. Ziegler D, Dannehl K, Muhlen H et al. Prevalence of cardiovascular autonomic dysfunction assessed by spectral analysis. *Diabet Med*. 2019; 36(3):362-370.
11. Singh JP, Larson MG, O'Donnell CJ et al. Association of hyperglycemia with reduced heart rate variability. *Diabetes Care*. 2018; 41(8):1600-1607.
12. Braffett BH, El Ghormli L, Martin C et al. Cardiovascular autonomic neuropathy and cardiovascular disease risk. *Cardiovasc Diabetol*. 2022; 21:98.
13. Dimitropoulos G, Tahrani AA, Stevens MJ. Cardiac autonomic neuropathy in diabetes mellitus. *World J Diabetes*. 2015; 6(1):17-39.
14. Low PA, Tomalia VA. Autonomic nervous system function. *J Clin Neurophysiol*. 2015;32(3):213-221.
15. Balcioglu AS, Muderrisoglu H. Diabetes and cardiac autonomic neuropathy: Diagnosis and treatment. *World J Diabetes*. 2015; 6(1):80-91.

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