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Original Research

Altered Sympathetic Reactivity in Offspring of Diabetic Parents: Evidence of Early Autonomic Dysfunction

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Abstract
Background: Diabetes mellitus (DM) is a major metabolic disorder associated with increased sympathetic nervous system activity and cardiovascular dysfunction. Offspring of diabetic parents are at a higher risk of developing diabetes and hypertension later in life due to genetic predisposition and early autonomic imbalance. Early evaluation of autonomic functions can help identify individuals at risk before clinical disease onset. ***Objectives***: To assess and compare the sympathetic reactivity in offspring of diabetic and non-diabetic parents using the Hand-Grip Test (HGT) and Cold-Pressor Test (CPT). ***Methods***: A total of 60 healthy subjects aged 18-25 years were included and divided into two groups: offspring of diabetic parents (n=30) and offspring of non-diabetic parents (n=30). Anthropometric data, baseline heart rate, and blood pressure were recorded. Sympathetic activity was evaluated by measuring changes in systolic and diastolic blood pressure during and after HGT and CPT. Statistical analysis was performed, and $p<0.05$ was considered significant. ***Results***: No significant difference was observed in anthropometric parameters between the two groups. However, baseline heart rate, systolic, and diastolic blood pressure were significantly higher in offspring of diabetic parents ($p<0.05$). The rise in blood pressure during HGT and CPT was comparable between both groups ($p>0.05$). In offspring of diabetic parents, recovery systolic blood pressure remained significantly higher following both tests ($p<0.05$), indicating delayed normalization of sympathetic activity. ***Conclusion***: Offspring of diabetic parents exhibit altered sympathetic responses and delayed recovery of blood pressure following sympathetic stimulation, suggesting subclinical autonomic dysfunction. Regular assessment of autonomic function in these individuals may help in early identification and prevention of diabetes and hypertension.

Keywords: *Diabetes mellitus, Sympathetic nervous system, Hand-Grip Test, Cold-Pressor Test, Autonomic function, Blood pressure recovery.*

INTRODUCTION

Diabetes mellitus (DM) is a chronic metabolic disorder characterized by increased blood glucose levels, leading to serious complications involving the heart, arteries, veins, eyes, kidneys, and nervous system. Approximately 422 million people worldwide are diabetic, with type 2 diabetes being the most common form, typically affecting older adults. Over the last 30 years, the prevalence of type 2 diabetes has increased markedly across all countries (1).

Due to the rising incidence of diabetes in India, the country is often referred to as the "Diabetes Capital of the World" (2). Patients with DM and associated microvascular complications are at significantly higher risk of accelerated vascular stiffness, which may culminate in neurological and cardiovascular events and premature death (3).

Alterations in microvascular function may occur even before overt hyperglycemia and structural vascular changes manifest. DM induces characteristic microvascular changes, including thickening of capillary basement membranes and alterations in arterioles, veins, and capillaries of the renal, visual, cardiac, integumentary, and muscular systems. This thickening leads to impaired vascular performance, contributing to clinical issues such as cardiovascular disease, delayed wound healing, and chronic inflammation (4).

The autonomic nervous system (ANS) is a complex network of neurons and pathways that regulate the functioning of various organ systems in the body. Its primary role is to maintain physiological homeostasis and to mediate adaptive responses to internal and external environmental changes (5). The sympathetic nervous system (SNS) is strongly activated during emotional states such as anger or stress. For instance, stimulation of the hypothalamus can evoke a "sympathetic alarm reaction," causing widespread sympathetic discharge and rapid physiological changes (6).

Grip strength testing is a simple, reliable, and widely used assessment in clinical practice. It provides a quick measure of muscle performance and can serve as a baseline for monitoring changes over time (6). Studies have shown that autonomic imbalance, particularly increased sympathetic tone, is observed in the offspring of hypertensive parents (7). Young, normotensive individuals with a family history of hypertension may also exhibit traits such as higher body weight and elevated blood pressure (8).

Sympathetic activation leads to an increase in blood pressure (BP) during stress, followed by recovery to baseline levels once the stress is withdrawn. Individuals with poor autonomic variability show exaggerated BP responses to stress and delayed recovery. Such individuals are at higher risk of developing hypertension and diabetes at an early age (8).

Aim and Objective

To study autonomic variability in non-diabetic offspring of diabetic parents]

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Materials and Methods

This cross-sectional study was conducted in the Department of Physiology, Era's Lucknow Medical College, Era University, Lucknow. Ethical approval was obtained from the Institutional Ethics Committee prior to commencement.
A total of 60 participants were included:
Cases: 30 non-diabetic offspring (aged 18-25 years) of diabetic parents.
Controls: 30 non-diabetic offspring (aged 18-25 years) of non-diabetic parents.
Both groups were age- and sex-matched.

Inclusion Criteria

Young and healthy males and females aged 18-25 years.
For cases: Offspring of diabetic parents.
For controls: Offspring of non-diabetic parents.
Participants willing to provide written informed consent.

Exclusion Criteria

Subjects aged 18-25 years with any of the following were excluded:
History of diabetes mellitus.
History of chronic disorders such as cardiovascular disease, tuberculosis, or hypertension.
History of chronic alcoholism or tobacco use.
Subjects on drug therapy (e.g., corticosteroids, beta-blockers).
Unwillingness to give consent.

Methodology

After fulfilling inclusion and exclusion criteria, a detailed clinical history of participants and their parents was obtained, followed by a general physical and systemic examination.
Only healthy, non-smoking, non-alcoholic individuals with normal BP were included. The procedure and purpose of the study were clearly explained, and written informed consent was taken from each participant.
Measurement of Blood Pressure
Participants were seated comfortably for 5 minutes before testing. Baseline BP was recorded using a digital BP monitor (OMRON HEM-FL31).
Handgrip Dynamometer Test
A handgrip dynamometer was used to measure maximal isometric tension (Tmax).
After recording baseline BP, participants were instructed to grip the dynamometer with maximal effort.
The highest reading of three attempts was recorded as Tmax.
30% of Tmax was maintained for 1 minute, followed by BP measurements immediately and after 3 minutes (recovery phase).

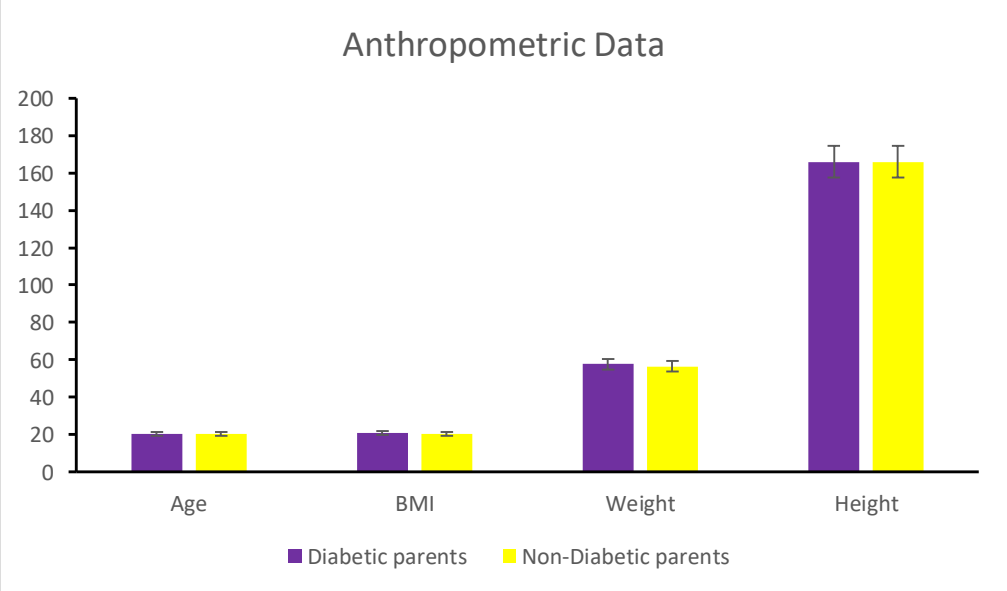
Cold Pressor Test

Participants were asked to immerse one hand (without BP cuff) into cold water at 4°C for 1 minute.
BP was measured from the opposite arm at 1 minute and again at 5 minutes post-stimulus.
Any discomfort or inability to continue was noted.
Body Mass Index (BMI)
BMI was calculated using the WHO (10) criteria:
BMI=Weight(kg)/(〖Height〗^2 〖(m〗^2))
Weight was measured using a standardized weighing machine, and height was measured with a wall-mounted height chart in the physiology laboratory.

Results

Table 1: Descriptive Statistics of Anthropometric Data

S.No.	Variable	Diabetic Parents (n = 30)	Non-Diabetic Parents (n = 30)	P value
1	Age (years)	20.17 ± 1.97	20.30 ± 1.92	p > 0.05 (NS)
2	Weight (kg)	57.60 ± 11.17	56.17 ± 9.46	p > 0.05 (NS)
3	Height (m)	1.66 ± 0.09	1.66 ± 0.09	p > 0.05 (NS)
4	BMI (kg/m²)	20.84 ± 3.30	20.35 ± 2.49	p > 0.05 (NS)



Interpretation:

As observed in Table 1, there was no statistically significant difference in the anthropometric parameters (age, weight, height, and BMI)

between the two groups.

Table 2: Descriptive Statistics of Baseline Data

S.No.	Variable	Diabetic (n = 30)	Non-Diabetic (n = 30)	P value
1	Heart Rate (beats/min)	76.13 ± 9.13	81.20 ± 9.36	p < 0.05 (S)
2	30% of Maximum Voluntary Contraction (kg)	13.63 ± 2.62	12.13 ± 3.29	p > 0.05 (NS)
3	Baseline Systolic BP (mmHg)	125.13 ± 7.23	113.20 ± 7.59	p < 0.05 (S)
4	Baseline Diastolic BP (mmHg)	78.47 ± 4.78	74.33 ± 6.39	p < 0.05 (S)

Interpretation:
As shown in Table 2, the groups were comparable regarding muscle effort (30% MVC). However, heart rate and baseline systolic and diastolic BP were significantly higher in offspring of diabetic parents compared to non-diabetic controls, indicating increased baseline sympathetic activity.

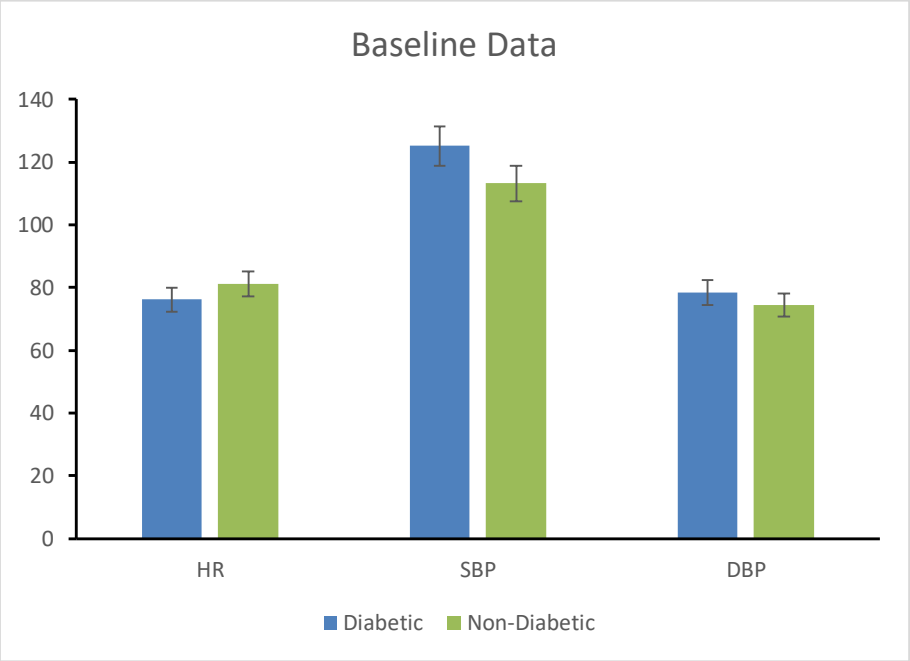


Table 3: Comparison of Change in Blood Pressure During Stress Tests

S.No.	Variable	Diabetic (n = 30)	Non-Diabetic (n = 30)	P value
1	Rise in SBP during Handgrip Test	17.80 ± 4.74	17.27 ± 3.50	p > 0.05 (NS)
2	Rise in DBP during Handgrip Test	11.13 ± 1.89	12.07 ± 2.94	p > 0.05 (NS)
3	Rise in SBP during Cold Pressor Test	17.07 ± 2.94	17.27 ± 2.00	p > 0.05 (NS)
4	Rise in DBP during Cold Pressor Test	11.30 ± 1.47	10.77 ± 1.01	p > 0.05 (NS)

Interpretation:
Table 3 shows no statistically significant difference in the rise of systolic or diastolic BP during either the handgrip or cold pressor tests between the two groups.

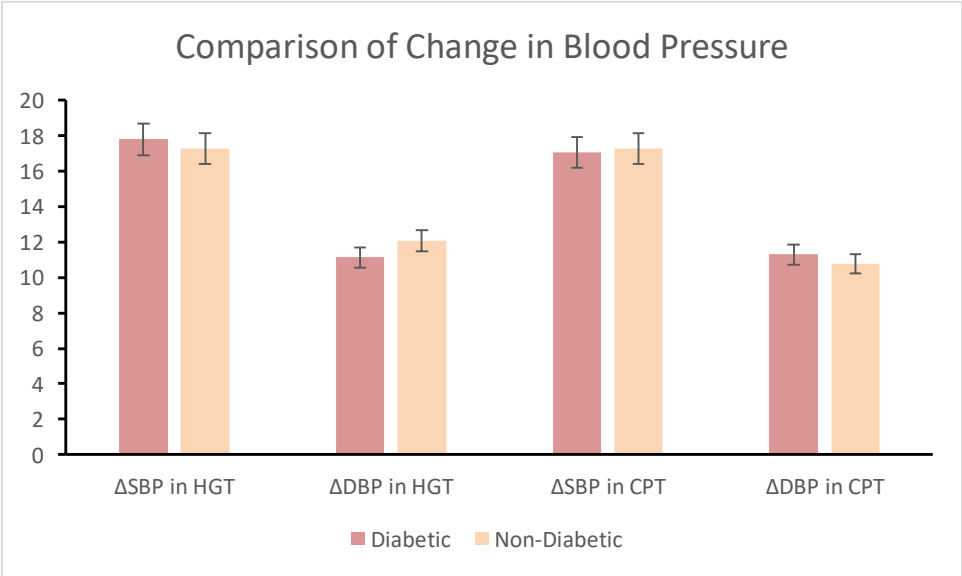


Table 4: Comparison of Baseline and Recovery Blood Pressure in Offspring of Diabetic Parents

S.No.	Variable	Baseline (Mean ± SD)	Recovery (Mean ± SD)	P value
1	SBP in Handgrip Test	125.15 ± 7.23	126.67 ± 7.48	p < 0.05 (S)
2	DBP in Handgrip Test	78.47 ± 4.77	79.27 ± 5.15	p > 0.05 (NS)
3	SBP in Cold Pressor Test	125.16 ± 7.23	126.13 ± 6.86	p < 0.05 (S)
4	DBP in Cold Pressor Test	78.47 ± 4.77	75.20 ± 6.11	p < 0.05 (S)

Interpretation:
As observed, the systolic BP increased significantly in both handgrip and cold pressor recovery phases among offspring of diabetic parents. The diastolic BP increased insignificantly after the handgrip test but showed a significant decrease following the cold pressor test. This indicates a delayed recovery and altered autonomic control.

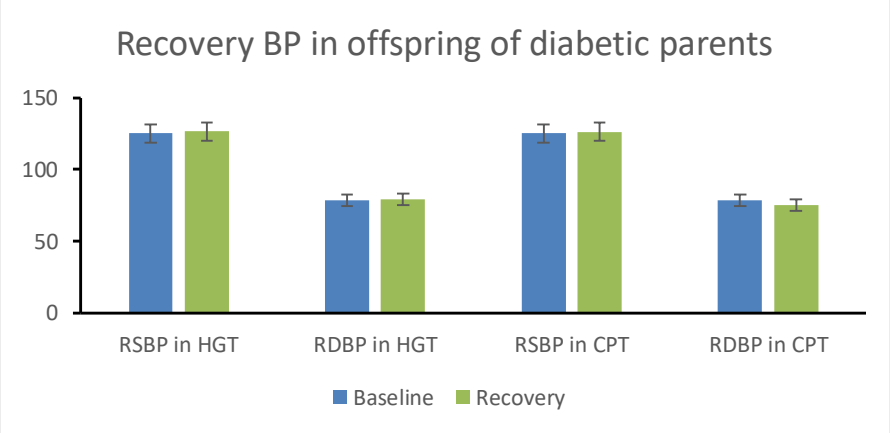
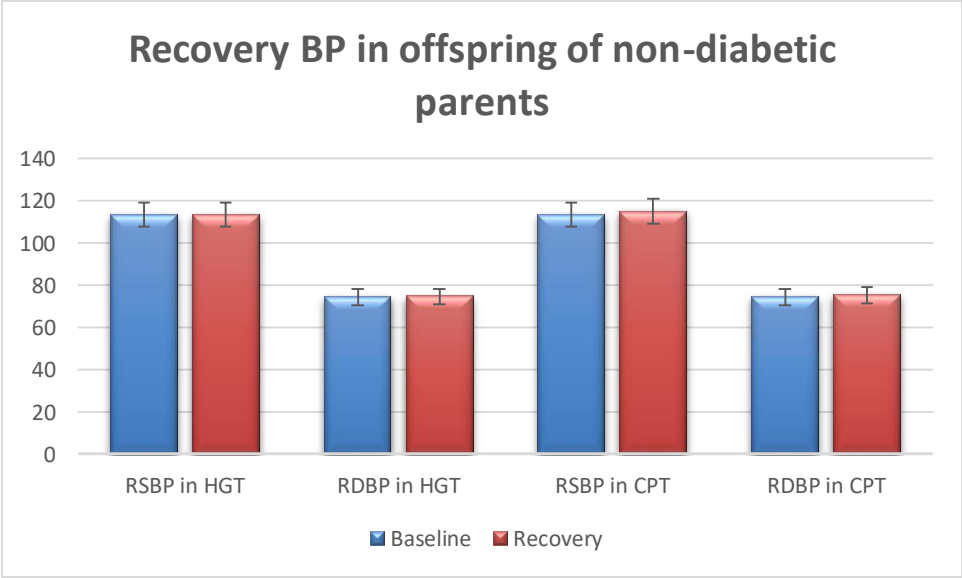


Table 5: Comparison of Baseline and Recovery Blood Pressure in Offspring of Non-Diabetic Parents

S.No.	Variable	Baseline (Mean ± SD)	Recovery (Mean ± SD)	P value
1	SBP in Handgrip Test	113.20 ± 7.58	113.20 ± 7.09	p > 0.05 (NS)
2	DBP in Handgrip Test	74.33 ± 6.39	74.53 ± 6.78	p > 0.05 (NS)
3	SBP in Cold Pressor Test	113.20 ± 7.58	114.93 ± 7.23	p < 0.05 (S)
4	DBP in Cold Pressor Test	74.33 ± 6.39	75.20 ± 5.74	p > 0.05 (NS)

Interpretation:
As seen in Table 5, there was no significant change in BP during recovery after the handgrip test among offspring of non-diabetic parents. However, a significant rise in SBP was observed after the cold pressor test, while changes in DBP were not significant.



Discussion

Diabetes mellitus (DM) and cardiovascular diseases are among the most common disorders in the elderly and are leading causes of mortality worldwide. Both conditions are characterized by increased sympathetic nervous system activity (9).

Several studies have indicated that offspring of diabetic parents are at a greater risk of developing diabetes, particularly if a grandparent is also diabetic (10). Diabetes is associated with chronic hyperglycemia and predisposes individuals to complications such as diabetic neuropathy due to genetic and metabolic factors (11).

Proper balance between sympathetic and parasympathetic tone is essential for normal visceral and cardiovascular function. Imbalance between these systems increases susceptibility to hypertension, myocardial infarction, and stroke.

In the present study, anthropometric parameters were comparable between the two groups, ruling out obesity or body size as confounding factors. However, heart rate and baseline BP were significantly higher in offspring of diabetic parents, indicating latent sympathetic overactivity even in apparently healthy individuals.

In both the handgrip and cold pressor tests, the recovery blood pressure remained elevated in the offspring of diabetic parents, whereas it returned to baseline in controls. This finding suggests prolonged sympathetic activation and delayed parasympathetic recovery in the study group – a potential early sign of autonomic dysfunction.

These observations are consistent with previous reports indicating autonomic imbalance in offspring of diabetics and hypertensives. Prolonged sympathetic activity may contribute to early onset of hypertension and insulin resistance, which are key precursors to metabolic syndrome and diabetes mellitus.

CONCLUSION

This study suggests that recovery time of blood pressure following handgrip and cold pressor tests serves as a useful marker for detecting subclinical autonomic nervous system dysfunction in offspring of diabetic parents.
Such individuals should be monitored regularly for early detection of diabetes mellitus and hypertension, enabling timely preventive interventions.

Limitations

- The sample size of this study was relatively small; therefore, the findings may not be generalizable.
- Further studies with larger sample sizes and inclusion of additional autonomic function tests (e.g., heart rate variability, Valsalva manoeuvre) are recommended to better assess sympathetic and parasympathetic changes.
- Longitudinal follow-up would help determine whether autonomic imbalance progresses to clinical diabetes or hypertension.

Conflict of Interest–Nil.

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