

RESEARCH ARTICLE

Effect of diabetes mellitus on resting heart rate, postural blood pressure, Valsalva ratio, and blood pressure response to hand grip test

Prashanth Narayan Dixit¹, Vijaynath Itagi¹, Raghavendra Babu Y P², Prakash S B¹

¹Department of Physiology, Koppal Institute of Medical Sciences, Koppal, Karnataka, India, ²Department of Forensic Medicine, Koppal Institute of Medical Sciences, Koppal, Karnataka, India

Correspondence to: Vijaynath Itagi, E-mail: dritagi@gmail.com

Received: July 08, 2018; Accepted: July 24, 2018

ABSTRACT


Background: Cardiac autonomic neuropathy is a common and serious complication in diabetic patients; the aim of the present study is to assess the effect of diabetes mellitus on heart rate (HR), postural blood pressure, Valsalva maneuver, and blood pressure response to handgrip test and its comparison with the normal individuals. **Aims and Objective:** The objective of the study is to detect the autonomic dysfunctions in the diabetic patients as early as possible so that later complications of the disease can be prevented and to prevent the mortality and morbidity of diabetes mellitus. **Materials and Methods:** Study is done involving 75 diabetic and 50 nondiabetic individuals after taking the written consent from them. Where the selection criteria of the individuals are when they do not have any other complications and recently diagnosed diabetic people. In these individuals cardiovascular reflex tests were carried out which include resting HR, effect of standing on blood pressure, Valsalva maneuver, and hand grip test. **Results:** Our study showed that there is a significant increase in the resting HR in diabetic persons than the normal ($P < 0.01$). When blood pressure in compared to resting to standing position there is a significant decrease in the diastolic blood pressure in diabetic patients than the controls. When we asked both the groups to do Valsalva maneuver through the Valsalva ratio remained in the normal range, but it is significantly reduced in diabetic patients. When we studied the hand grip test in both the groups, we found out that there is an increase in both systolic and diastolic blood pressure in controls then the diabetic persons. These tests results will suggest that in diabetic peoples there will be autonomic neuropathy. **Conclusion:** In conclusion, diabetic autonomic neuropathy is a serious and common complication of diabetes mellitus, these cardiac reflex tests will help us in early diagnose and proper treatment of the diabetic patients. Only one test is not sufficient, but tougher these tests will help drastically, these tests will be more economical when compared to diabetic compilation treatment.

KEY WORDS: Diabetes; Postural Blood Pressure; Valsalva Maneuver; Hand grip Test; Cardiac Autonomic Neuropathy

INTRODUCTION

Diabetes prevalence is increasing globally day by day; now it is estimated that India would be having the highest

population of diabetes by 2025 and is all set to become the “Diabetic Capital” of world.^[1] It is a major cause of disability and death, usually, people who suffer from diabetes are unaware of the disease until they experience the side effect of this disease. Diabetic neuropathies are a long-term complication of diabetes which affect up to 50% of the patients.^[2-4] Common neuropathies are sensorimotor and autonomic neuropathies. Studies showed that heart rate (HR) of rats following pharmacological blockade of the sympathetic and parasympathetic system the resting intrinsic HR fell around 25% in diabetic animals.^[5] Further studies compared untreated and insulin-treated diabetic

Access this article online	
Website: www.njppp.com	Quick Response code 
DOI: 10.5455/njppp.2018.8.0722924072018	

National Journal of Physiology, Pharmacy and Pharmacology Online 2018. © 2018 Vijaynath Itagi, *et al.* This is an Open Access article distributed under the terms of the Creative Commons Attribution 4.0 International License (<http://creativecommons.org/licenses/by/4.0/>), allowing third parties to copy and redistribute the material in any medium or format and to remix, transform, and build upon the material for any purpose, even commercially, provided the original work is properly cited and states its license.

rats where arterial pressure, HR, and its variability showed that autonomic control of HR and mean arterial pressure was reversible with good glycemic control and insulin treatment.^[6] In 1892 Eichorst was the first person to suggest that persistent tachycardia in diabetic patients is due to damage to the vagus nerve.^[7] Later Rundles said that DAN is responsible for tachycardia.^[8] Sharpey-Schfer and Taylor found that in diabetic neuropathy Valsalva maneuver was abnormal.^[9] Usually, normal heartbeat will be irregular and variation of HR can be measured by various techniques.^[10-12] However, most sensitive measurement is during repeated deep breathing.^[13] From sitting to standing up HR changes which are impaired in diabetic neuropathy patients, normally HR increases and overshoots but in diabetic patients, this overshoot is lost, and HR slowly increases or sometimes totally absent, this observation is the basis of another autonomic function tests.^[11,12,14,15]

Many studies show that resting HR in excess of 95 beats per minutes is seen in diabetic patients, where resting tachycardia, fixed HR, and postural hypotension are characteristic of diabetic autonomic neuropathy.^[16] Arbitrarily it is defined as systolic blood pressure (BP) fall of 30 mm of Hg or more on standing, postural weakness, faintness which are the symptoms which may get aggravated with diuretics, tricyclic antidepressants, and Insulin too may aggravate postural hypotension.^[17] Masking of postural hypotension can occur with fluid retention in association with congestive cardiac failure or the nephritic syndrome.^[16] Fall of cardiac output and arterial blood pressure due to venous pooling is the consequence of standing up; usually, this will overcome by vasoconstriction and acceleration of the cardia but in diabetic patients, failure of vasoconstriction, especially in splenic area and bit subcutaneous area, is a cause of postural hypotension, which is probably due to the damage of sympathetic postganglionic innervation of resistance vessels with loss of reflex vasoconstriction.^[18]

Hand grip test usually raises BP due to increased HR dependent on cardiac output and vascular resistance. As in diabetic autonomic neuropathy, normal reflex pathways will be damaged so this rise in BP will be abnormally small. Hand grip dynamometer is used to perform this hand grip test where BP is measured each minute. Difference of diastolic blood pressure (DBP) before starting and just before the release of the dynamometer is the measure of response.

Clinical symptoms of diabetes usually manifest after a long time, but subclinical dysfunctions of the autonomic nervous system (ANS) are seen within a year of diagnosis. These cardiac autonomic neuropathy markers will develop early so these markers can be used to study the effect of treatment on the patients, or these markers will be important in recognition and early treatment of the diabetes mellitus.

Objectives of the Study

The present study is carried out to evaluate diagnostic tests of diabetic autonomic neuropathy in both symptomatic and asymptomatic diabetic patients and normal individuals. It is possible to detect the autonomic dysfunctions in the diabetic patients as early as possible so that complications of the disease can be prevented and to prevent the mortality and morbidity of diabetes mellitus.

MATERIALS AND METHODS

This study is done involving 75 diabetic patients and 50 nondiabetic persons, including both males and females between 30 and 50 years without any other treatment such as antihypertensive, vasodilators, phenothiazines, and β -Blockers and who were attending the Outpatient Department in KIMS Teaching Hospital KIMS Koppal. Alcoholics, smokers, persons with heart diseases and heart failures, and those with diabetic complications were not included in the study.

Moreover, relevant Clearance from the Institutional Ethical Committee was obtained before undertaking the study.

Pre-tested Performa is used to collect the relevant consent and history of the patient which include clinical history, medication, and any complaints. Participants were asked not to drink caffeine-containing drinks 2 h before coming for the study

The patients are placed supine on an examination table and allowed to rest for 5 min, they will be asked to breathe regularly around 10 breaths per minute using metronome, and then they will be connected to electrocardiogram (ECG) machine. The ECG recording is done and resting HR is calculated from this.

HR Response to Standing

After completing the Valsalva procedure, the patient is allowed to rest for 15 min, after which the ECG recording is done for about 30 s with the patient still in the supine position. With ECG machine is running, the patient is asked to stand up. After the ECG baseline become normal, the 15th beat and the 30th beat after standing up is marked. The characteristic HR response can be expressed by the 30:15 ratio, which will be the ratio of the longest R-R interval around the 30th beat after starting to stand up to the shortest R-R interval around the 15th beat.

Blood Pressure Response to Standing

The patient is again allowed to assume a supine position, and a recording of blood pressure is done in the supine position. The patient is then asked to stand up, and blood pressure is recorded at 0 and 1 min intervals.

Descriptive data are presented as means±standard deviation. Test of the normal distribution of data was analyzed. Student *t*-test was used to compare the differences between values. The accepted level of significance for differences was equal to or <0.05 for all tests ($P < 0.05$).

RESULTS

When we analyzed we found that the total number of subjects were 125 and the age of subjects ranged from 30 to 60 years. In which of the 50 normal individuals, 29 subjects were in the age group of 30–39 years, 16 subjects were in the age group of 40–49 years, 3 subjects were in the age group of 50–59 years, and 2 subjects were in the age group >60 years. Similarly in diabetic patients of 75, 18 subjects were in the age group of 30–39 years, 31 subjects were in the age group of 40–49 years, 23 subjects were in the age group of 50–59 years, and 3 subjects were in the age group >60 years [Table 1].

On the comparison between controls and diabetic cases, the resting HR was significantly higher in diabetics than normal ($P < 0.01$). Whereas HR response to standing when compared

it is found that there is a significant reduction in the diabetic persons than the normal ($P < 0.01$) [Table 2].

When the blood pressure response to supine to standing was evaluated, there was a very much significant decrease in the DBP in diabetics than controls ($P < 0.01$) [Table 3].

The Valsalva ratio was decreased in diabetics as compared to controls ($P < 0.01$). Although the values of Valsalva ratio were within the normal range in both the groups, the difference observed between the groups was statistically significant ($P < 0.01$) [Table 4].

During hand grip test, when the blood pressure was compared with the controls and cases, there was a significant increase in the systolic and DBP in controls during the test ($P < 0.01$) [Table 5]. Ratio of HR on standing (30:15) significantly decreased in cases as compared to controls ($P = 0.01$).

DISCUSSION

There will be the significant negative impact on the quality and survival rate in diabetic people, but Diabetic Autonomic Neuropathy (DAN) is the least understood and recognized complications of diabetes mellitus, which will involve the entire ANS.

Symptoms of autonomic neuropathy occur long after the onset of diabetes, but symptoms of autonomic dysfunction are common. These symptoms may be due to other causes also.

DAN can be assessed by focusing on symptoms and dysfunctions of the specific organ system; it is more important

Table 1: Age-wise distribution

Age group (years)	Normal subjects	Diabetic subjects
30–39	29	18
40–49	16	31
50–59	3	23
60+	2	3
Total	50	75
Range	30–60	30–62

Table 2: Resting HR and response to standing

Parameters	Cases (n=75) Mean±SD	Controls (n=50) Mean±SD	t-test value	P-value
Resting HR	87.49±3.21	76.48±4.35	16.278	<0.001
HR response to standing	1.049±0.007	1.056±0.015	-3.513	0.001

HR: Heart rate, SD: Standard deviation

Table 3: Blood pressure response to standing

Parameters	Cases (n=75) Mean±SD	Controls (n=50) Mean±SD	t-test value	P-value
PHSup-SBP	123.55±8.58	123.88±7.19	-0.227	0.821
PHSup-DBP	74.64±4.14	75.88±4.81	-1.539	0.126
PHStn-SBP	111.55±10.27	114.36±7.75	-1.648	0.102
PHStn-DBP	69.57±5.16	80.52±5.58	-11.245	<0.001

SDB: Systolic blood pressure, DBP: Diastolic blood pressure, SD: Standard deviation

Table 4: Valsalva ratio

Valsalva ratio	Cases (n=75) Mean±SD	Controls (n=50) Mean±SD	t-test value	P-value
	1.244±0.026	1.273±0.015	-7.119	<0.001

SD: Standard deviation

Table 5: Response to hand grip test

Parameters	Cases (n=75) Mean±SD	Controls (n=50) Mean±SD	t-test value	P-value
HGTRest SBP	116.48±5.39	113.56±7.060	2.617	0.010
HGTRestDBP	73.84±3.99	75.36±4.58	-1.964	0.052
HGTDrestSBP	126.77±5.75	134.84±6.44	-7.321	<0.001
HGTDRest DBP	82.99±4.76	94.16±4.74	-12.878	<0.001

SDB: Systolic blood pressure, DBP: Diastolic blood pressure, SD: Standard deviation

to focus on this because of life-threatening consequences of this complication of cardiovascular autonomic functions.

In this study, we have used some of the cardiovascular reflex tests they are:

1. Resting HR,
2. Deep breathing test,
3. Handgrip test,
4. Valsalva maneuver,
5. Recording of blood pressure from lying to standing.

In our study, we saw that there is a significant increase in the resting HR in diabetic patients than controls when we studied the response of HR to standing there is a significant reduction is seen in diabetic persons. Our study showed that there is a significant decrease in the DBP in diabetic patients when they stand up, comparing the Valsalva ratio it is observed that it is very much significantly reduced in diabetic individuals. When we study the blood pressure response to Handgrip test, we observed that there is a significant decrease in both systolic and DBP in diabetic persons than the normal persons.

In our study, resting HR in diabetic patients was significantly high, which might be due to damage to the parasympathetic nervous system, many studies have shown the same results^[19,20] which is in coordination with our study. Response of HR on standing where there is a significant reduction in diabetic persons is seen many studies^[15] supports our study which might be due to damage to the sympathetic and parasympathetic reflex pathways. Low *et al.*^[21] and Langer *et al.*^[22] also found that there is a decrease in the DBP in diabetic patients when they stand up from laying position, which is in concurrence with our study, where there will be damage to efferent sympathetic vasomotor fibers in the splanchnic vasculature. When Valsalva ratio is observed which is a most complex reflex involving ANS supplying to baroreceptor and the heart, it is significantly reduced in the diabetic individuals. Many studies supports our findings^[22,23] response of the blood pressure to handgrip test where both systolic and DBP was significantly decreased in diabetic persons, Ewing *et al.*^[9] showed the same results, which might be due to HR and cardiac output increases when normal person performs the isometric exercise, where blood pressure response is more marked. In diabetic patients, this response is not seen because of the damage to ANS which decrease the vascular resistance and impaired sympathetic activity.

Limitation of the Study

Only hindrance is only one test alone is not sufficient in detecting the autonomic dysfunctions, but hand grip test and Valsalva maneuver, shown promise as a useful screening tests for diabetic patients. Which is useful in assessing the autonomic neuropathy. However, a larger prospective study is required in evaluating the usefulness of these tests.

CONCLUSIONS

This study consists of 75 newly detected type 2 diabetic patients without any symptoms of autonomic dysfunctions. One of the serious complications of diabetes mellitus is Autonomic dysfunction; this can affect daily activities and sometimes have lethal outcomes. Proper history and physical examination may not help in early detection of autonomic dysfunctions and thus recommend for the use of non-invasive tests, which will not diminish the clinical importance but it will enhance the clinical assessment, which has also shown the efficacy and also proved economical when compared to the incremental costs of treating either a detected complications or more catastrophic event that could eventually occur.

REFERENCES

1. King H, Aubert RE, Herman WH. Global burden of diabetes, 1995-2025: Prevalence, numerical estimates, and projections. *Diabetes Care* 1998;21:1414-31.
2. Dyck PJ, Kratz KM, Karnes JL, Litchy WJ, Klein R, Pach JM, *et al.* The prevalence by staged severity of various types of diabetic neuropathy, retinopathy, and nephropathy in a population-based cohort: The Rochester diabetic neuropathy study. *Neurology* 1993;43:817-24.
3. Young MJ, Boulton AJ, MacLeod AF, Williams DR, Sonksen PH. A multicentre study of the prevalence of diabetic peripheral neuropathy in the United Kingdom hospital clinic population. *Diabetologia* 1993;36:150-4.
4. Kumar S, Ashe HA, Parnell LN, Fernando DJ, Tsigos C, Young RJ, *et al.* The prevalence of foot ulceration and its correlates in type 2 diabetic patients: A population-based study. *Diabet Med* 1994;11:480-4.
5. Cameron NE, Cotter MA. Metabolic and vascular factors in the pathogenesis of diabetic neuropathy. *Diabetes* 1997;46 Suppl 2:S31-7.
6. Hoeldtke RD, Bryner KD, McNeill DR, Hobbs GR, Riggs JE, Warehime SS, *et al.* Nitrosative stress, uric acid, and

- peripheral nerve function in early type 1 diabetes. *Diabetes* 2002;51:2817-25.
7. Clarke BF, Ewing DJ, Campbell IW. Diabetic autonomic neuropathy. *Diabetologia* 1979;17:195-212.
 8. Rundles RW. Diabetic neuropathy: General review with report of 125 cases. *Med (Baltimore)* 1945;24:111-60.
 9. Ewing DJ, Campbell IW, Clarke BF. The natural history of diabetic autonomic neuropathy. *Q J Med* 1980;49:95-108.
 10. Cryer PE, Silverberg AB, Santiago JV, Shah SD. Plasma catecholamines in diabetes. The syndromes of hypoadrenergic and hyperadrenergic postural hypotension. *Am J Med* 1978;64:407-16.
 11. Faerman I, Faccio E, Milei J, Nuñez R, Jadzinsky M, Fox D, *et al.* Autonomic neuropathy and painless myocardial infarction in diabetic patients. Histologic evidence of their relationship. *Diabetes* 1977;26:1147-58.
 12. Ewing DJ, Campbell IW, Burt AA, Clarke BF. Vascular reflexes in diabetic autonomic neuropathy. *Lancet* 1973;2:1354-6.
 13. Sundkvist G, Almér LO, Lilja B. Respiratory influence on heart rate in diabetes mellitus. *Br Med J* 1979;1:924-5.
 14. Hilsted J, Jensen SB. A simple test for autonomic neuropathy in juvenile diabetics. *Acta Med Scand* 1979;205:385-7.
 15. Ewing DJ, Campbell IW, Murray A, Neilson JM, Clarke BF. Immediate heart-rate response to standing: Simple test for autonomic neuropathy in diabetes. *Br Med J* 1978;1:145-7.
 16. Fraser DM, Campbell IW, Ewing DJ, Murray A, Neilson JM, Clarke BF, *et al.* Peripheral and autonomic nerve function in newly diagnosed diabetes mellitus. *Diabetes* 1977;26:546-50.
 17. Watkins PJ, Mackay JD. Cardiovascular effects, cardiac denervation in diabetic neuropathy. *Ann Intern Med* 1980;92:304-307.
 18. Hosking DJ, Benntt T, Hampton HJ. Diabetic autonomic neuropathy. *Diabetes* 1978;27:1043.
 19. Tornlinson DR. Polyols and myointosital in diabetic neuropathy of mice and men. *Mayo Clin Proc* 1989;64:1030.
 20. Veglio M, Sivieri R, Chinaglia A, Scaglione L, Cavallo-Perin P. QT interval prolongation and mortality in type 1 diabetic patients: A 5-year cohort prospective study. Neuropathy study group of the Italian society of the study of diabetes, Piemonte affiliate. *Diabetes Care* 2000;23:1381-3.
 21. Low PA, Walsh JC, Huang CY, McLeod JG. The sympathetic nervous system in diabetic neuropathy. A clinical and pathological study. *Brain* 1975;98:341-56.
 22. Langer A, Freeman MR, Josse RG, Steiner G, Armstrong PW. Detection of silent myocardial ischemia in diabetes mellitus. *Am J Cardiol* 1991;67:1073-8.
 23. American Diabetes Association. Consensus statement: Autonomic nervous system testing. *Diabetes Care* 1992;15 Suppl 3:1095-103.

How to cite this article: Dixit PN, Itagi V, Babu YPR, Prakash SB. Effect of diabetes mellitus on resting heart rate, postural blood pressure, Valsalva ratio, and blood pressure response to hand grip test. *Natl J Physiol Pharm Pharmacol* 2018;8(10):1441-1445.

Source of Support: Nil, **Conflict of Interest:** None declared.