This journal is the official publication of Bangladesh Society of Physiologists (BSP)
Web URL: www.banglajol.info/index.php/JBSP

Abstracted /indexed in Index Copernicus, Director of Open Access Journal, HINARI Index Medicus for South East Asia Region, Google Scholar, 12OR, infobse index, Open J gate, Cite factor, Scientific indexing services

pISSN-1983-1213; e-ISSN-2219-7508

Article

Article information:
Received: March 2025
Accepted: June 2025
DOI:https://doi.org/10.3329/jbsp.v20i1.84054

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Cite this article:
Rahman F, Ferdousi S. Heart rate variability after deep relaxation in Type 2 Diabetes Mellitus patients: Non linear analysis. J Bangladesh Soc Physiol 2025;20(1): 32-38.

Heart rate variability after deep relaxation in Type 2 Diabetes Mellitus patients: Non linear analysis

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Abstract

Background: Autonomic nerve dysfunction has been noted in type 2 diabetes mellitus (T2DM). It needs not only medical management but also lifestyle modification. Regular practice of yoga based deep relaxation technique (DRT) cause improvement of autonomic nerve function by increasing heart rate variability (HRV) in healthy subjects. **Objective:** To observe the effect of yoga based DRT on non linear measures HRV by Poincare plot analysis in T2DM patients. **Methods:** This prospective interventional study was done in the Department of Physiology, Bangabandhu Sheikh Mujib Medical University (BSSMU), Dhaka in 2016 on 30 female diagnosed T2DM patients aged 50-55 years with duration of diabetes of 5-10 years. They performed DRT (20 minutes twice daily) for 3 months. 30 apparently healthy female with similar age who did not perform DRT or any other form of exercise, were included as control. To assess the cardiac autonomic nerve function, non linear HRV parameters were recorded by a data acquisition device Power Lab 8/35 (Australia) and Poincare analysis of data was auto generated by Lab chart software. HRV data of all subjects were collected at baseline (Pre) and also after 3 months of DRT(Post) in patients as well as in control without DRT. For statistical analysis, paired and independent sample t-test were used. **Results:** The pre-intervention non linear values of standard deviation of long axis(SD1) of scatterplots and standard deviation of short axis (SD2) of scatterplots ($p<0.001$) and SD1/SD2 ratio ($p<0.01$) were

significantly lower in all diabetic patients compared to control. After 3 months of DRT, there was significant increment in SD1, SD2 ($p<0.001$) and SD1/SD2 ratio ($p<0.05$) compared to their pre-intervention values. **Conclusion:** Cardiac autonomic nerve dysfunction may occur in T2DM and 3 month's regular exercise of DRT may improve cardiac autonomic nerve function and sympathovagal balance in Type 2 Diabetes Mellitus.

Key words: Deep relaxation technique, Autonomic nerve function, Heart rate variability, type 2 Diabetes Mellitus.

Introduction

Diabetes mellitus is characterized by hyperglycemia, which is a metabolic disorder resulting from impaired insulin effect.[1] This is related with increased cardiovascular morbidity and also autonomic neuropathy.[2,3] This worldwide health problem was anticipated that its incidence would increase to 7.7% by 2030.[4] Cardiac autonomic neuropathy (CAN) which is a subtype of the diabetic autonomic neuropathy is classified into its a subclinical and clinical stage.[5] The early stage of CAN or subclinical CAN is depicted by predominant damage to vagus nerve innervating the heart with consequent compensatory increase in sympathetic modulation of the heart resulting into cardiac autonomic imbalance.[6] Accordingly due to both parasympathetic and sympathetic denervation of heart which may exist with resting tachycardia, orthostatic hypotension, exercise intolerance and silent MI clinically CAN is occured.[5-7] Multi-factorial treatment strategy and life style modification have been advised for prevention of autonomic dysfunction in patients with type 2DM in many scientific literature. Contempt to this report, it cannot be reversed effectively by any treatment once the feature of CAN is clinically evident.[8] Therefore, it is important to intervene at its subclinical stage in diabetic patients.

Improvement of autonomic nerve function by different type of yoga based relaxation technique in both healthy volunteers and T2DM which brings balance in both physical and mental health as well as emotional and spiritual dimensions have been suggested in recent reports.[9-15] Significant improvement in angina, diabetes, hypertension, bronchial asthma, insomnia, rheumatoid arthritis has been observed with trial of these yoga based relaxation therapy. Deep relaxation technique (DRT), cyclic meditation (CM), shavasan and different other form of meditation have been studied in different relaxation techniques.[14-16] In accordance with this DRT has been ascribed as a procedure of meditation in which the subject adopts a posture comfortable for him/her usually in supine posture with eyes closed. Concentrating mind on breathing actually leads to the state of relaxation of body and mind.[14,16,17]

During subclinical phase, HRV can help in perceiving CAN before the disease is symptomatic.[5] This technique is non-invasive, accurate and generally reproducible.[18] Poincare analysis is the most commonly used nonlinear measures for clarification of HRV signals.[19,20] This method demonstrates complex behavior of beat to beat variability which cannot be measured by other methods of HRV.[19] The elliptical dispersion of R-R interval describe the relationship between two adjacent RR interval in this analysis, which includes three common indices those are SD1, SD2 and SD1/SD2. SD1, SD2 and SD1/SD2 represent parasympathetic activity, sympathetic activity and autonomic balance respectively. Reduced autonomic tone in T2DM is reported in previous studies.[3,21,22]

There are also reports of improvement of autonomic activities as a result of regular practice

of relaxation technique in healthy subjects and also in some diseases.[23-26] The information about the effect of relaxation technique in diabetic patients for its autonomic benefit is lacking and the impact of DRT on HRV by analysis of non linear measures in T2DM has not yet been published even though the benefit of relaxation technique on autonomic function has been tested in healthy subjects,[23-25,27-29] Therefore, the objective of this study was to investigate the impact of DRT by poincare analysis of HRV in T2DM to witness its potential for improvement of autonomic impairment in T2DM.

Methods

Design & setting

During 2016, the narrated prospective interventional study was conducted in the Department of Physiology, Bangabandhu Sheikh Mujib Medical University, Dhaka. The institutional review board of BSMMU has approved the protocol of this study.

Study participants & sampling

Thirty diagnosed female patients of T2DM (age: 50 to 55 years; HbA1C: 5-10%; 5 to 10 years duration of DM) were enrolled in this study following criteria of WHO[30] by purposive sampling from the Endocrinology Out Patient Department, BSMMU, after taking written informed consent. All these patients were only under oral hypoglycemic agents in addition to lifestyle modification. All patients were studied at baseline before beginning DRT and same patients were studied after performing DRT for 3 months. Among the relatives and attendants of patients, hospital staffs and also through personal contacts; age and physical activity matched 30 apparently healthy female previously never exposed to relaxation technique were recruited as control.

Exclusion criteria

Subjects with history of DAN, T1DM, diabetic retinopathy, nephropathy, hypertension, coronary artery diseases, epilepsy, migraine, psychiatric disorders, respiratory disorders, hypo & hyperthyroidism, consuming drugs with effect on autonomic nervous system function, yoga practitioners and athletes were excluded.

Data collection

The aim and objectives of the study were explained and they were encouraged for voluntary participation. Subsequently, a thorough clinical examination was done and family and medical history and also physical activity status were recorded in a prefixed data schedule.

For HRV recording, the finally selected subjects were prepared from one day prior to the test. They were advised to take their meal by 9.00 p.m. and have sound sleep and avoid any physical or mental stress and also sedative medications. In addition, they were advised to take light breakfast in the morning without tea and coffee and asked to report at the Autonomic Nerve Function Test Laboratory in the Department of Physiology of BSMMU between 9.00 a.m. to 11.00 a.m. on the day of test. For HRV measurement, the room temperature of the Autonomic Lab was maintained around 25ºc-28ºc and the subject was allowed to sit for 15 minutes to adjust with the lab conditions. Then, ECG was recorded on Lead II for 5 minutes, by Power Lab 8/35 (ADInstrument, Australia) from which non linear measures of HRV SD1,SD2 and SD1/SD2 was auto analysed by Lab chart software. Once before DRT then once after completion of 3 months of DRT, HRV data of all patients were recorded. Similarly, data of healthy subjects were recorded at baseline and after 3 months.

Intervention

The patients were asked to perform DRT twice daily for 3 months. For this purpose, patients were trained by demonstrating DRT for twenty minutes by the researcher. During this session, the participants laid in supine position with eyes closed, then each specific part of the body were

relaxed sequentially from tip of the toes to the neck with chanting "A-U-M".[15,23] They were requested to practice the steps twice daily in peaceful, lighted and well ventilated room at home and to report to the autonomic lab after 3 months for HRV data recording.

Statistical analysis

Data were expressed as mean and SE. For statistical analysis, Independent sample t-test was done to compare the mean values between control and T2DM at their baseline and after 3 months and also paired sample t-test was done to compare mean values of data between before and after intervention with DRT. All data were Analyzed by SPSS for windows, version 22.0 p value of < 0.05 was taken as statistically significant.

Results

In this study, all diabetic patients were similar to non diabetic subjects by mean age but not by BMI, though not all patients were overweight (Table I). In diabetic patients, at baseline, mean±SE resting pulse rate, systolic blood pressure(SBP) and diastolic blood pressure(DBP) were significantly ($p<0.01$, $p<0.001$) higher whereas SD1, SD2 and SD1/SD2 were significantly ($p<0.05$, $0<0.001$) lower in T2DM compared to control subjects (Table I and II). Again after 3 months of DRT, the resting pulse rate, SBP and DBP significantly decreased ($p<0.01$, $p<0.001$) in T2DM and found close to that of control subjects (Table I). On the other hand, the values of SD1, SD2 and SD1/SD2 significantly ($p<0.001$) increased in T2DM compared to baseline values but SD1, SD2 were significantly different from control but SD1/SD2 reached close to control value.

Table I: General characteristics in different groups (N=60)

Parameters	Control(n=30)		T2DM(n=30)	
	Baseline	After 3 months	Baseline	After 3 months
Age (years)	51.03±0.31	-	51.62±0.46	-
BMI (hg/m^2)	22.88±0.38	-	25.97±0.60*	-
Pulse (bpm)	81.23±1.05	74.61±0.26	86.50±0.86**	75.76±0.71$^{\#\$\$}$
SBP(mm of hg)	124.84±1.19	121.61±1.30	130.88±1.14**	130.96±1.33$^{\#\$}$
DBP(mm of hg)	76.35±0.85	72.97±0.79	83.97±1.00**	84.61±0.10$^{\#\$\$}$

Data were expressed as mean ± SE. Statistical analysis was done by independent sample t-test and paired sample t-test. BMI= Body mass index; SBP= systolic blood pressure; DBP=diastolic blood pressure; (*= control baseline vs T2DM baseline; #= control after 3 months vs T2DM after 3 months; $= T2DM baseline vs T2DM after 3 months; **=p<0.001; $=p<0.01; $$=p<0.001; N = number of subjects.)

Table II: Non linear measures of HRV in different groups (N=60)

Parameters	Control (n=30)		T2DM (n=30)	
	Baseline	after 3 months	Baseline	After 3 months
SD1	22.4±1.33	24.68±1.33	7.59±0.70**	19.43±1.71$^{\#\$\$}$
SD2	57.39±0.70	60.57±1.82	27.94±2.56**	52.01±1.75$^{\#\#\$\$}$
SD1/SD2	0.39±0.02	0.40±0.02	0.27±0.02*	0.37±0.02$^{\$}$

Data were expressed as mean ± SE. Statistical analysis was done by independent sample t-test and paired sample t-test. SD1= Standard deviation of short term RR interval variability, SD2= Standard deviation of long term RR interval variability, SD1/SD2 ratio= Ratio of short term and long term RR interval variability. (*= control baseline vs T2DM baseline; #= control after 3 months vs T2DM after 3 months; $= T2DM baseline vs T2DM after 3 months; * =p <0.05; **=p<0.001; #=p<0.05; ##= p<0.01; $= p<0.05; $$=p<0.001 N=number of subjects.)

Discussion

According to the assessment of the present study, cardiac autonomic nerve function in diagnosed Type 2 diabetic patients (T2DM) before and after deep relaxation technique for 3 months by analysis of non-linear measures of HRV and compared these results with control.

Significantly higher value of BMI in T2DM patients in this study compared to control group resemble to the observations in other similar study.[31-33] They suggested that BMI did not show any significant relationship with any of the HRV parameters in a correlation analysis in all groups of subjects.

In this study, the significant higher baseline values of pulse rate, SBP and DBP in diabetic patients compared to control indicate relatively higher sympathetic action in T2DM. DRT for 3 months reversed all these values towards parasympathetic predominance.

Higher values of pulse rate, SBP, DBP and lower values of SD1, SD2 and SD1/SD2 in diabetic patients in the recent study specify autonomic imbalance towards sympathetic predominance.[32,34-39]

After 3 months of DRT exercise, the significant decrement of pulse rate (12.42%), SBP (05.84%), and DBP (10.86%) in diabetic patients suggest improvement of cardiac autonomic nerve function which is consistent with findings of other investigators in healthy subjects after performing DRT and also in diabetics where diabetic patients performed slow breathing exercise.[11,39]

The significant increment of post exercise values of SD1 (155.99%), SD2 (86.15%) and SD1/SD2 (37.04%) was reported in this study which suggested improvement of autonomic harmony has been achieved by DRT. Though the value of SD1 and SD2 in DRT group after 3 months did not reach close to control group but SD1/SD2 was near to control and there was no significant difference in this parameter of autonomic balance between DRT group and control. These findings concluded that reduced parasympathetic and increased sympathetic activity in diabetic patients was effectively improved by intervention with DRT.

The exact mechanism involved in the autonomic response to this kind of yogic relaxation response has not been clearly explained. But the body of literature review proposed, the highly focused attention and willful muscle relaxation which is a part of the procedure of DRT probably created an integrated hypothalamic response by neural signal from increase activation of pre frontal cortex (PFC), anterior cingulated cortex.[16,40-43]

Conclusion

From this study, it can be concluded that impairment of autonomic balance with sympathetic predominance in T2DM was counterbalanced by exercising DRT for 3 months. Therefore, it is obvious that regular performance of deep relaxation technique is an effective measure to improve autonomic imbalance in its subclinical stage and can delay and prevent clinical autonomic neuropathy in Type 2 diabetes mellitus.

Acknowledgement

This study was partly funded by a research grant from Bangabandhu Sheikh Mujib Medical University.

Conflict of interest: None

Ethical approval

Ethical approval for this study was granted by the Institutional Review Board of BSMMU (memo number:2016/4708)

References

1. Ahmed KA, Muniandy S and Ismail IS. Type 2 diabetes and vascular complications: A pathophysiologic view. Biomed Res 2010;21(2): 147-55.
2. Gordon LA, Morrison EY, McGrowder DA, Young R, Fraser YTP, Zamora EM, Alexander-Lindo RL

and Irving RR. Effect of exercise therapy on lipid profile and oxidative stress indicators in patients with type 2 diabetes. BMC Compl Alter Med 2008 ;8 (21): 1-10.

3. Kudat H, Akkaya V, Sozen AB, Salman S, Demirel S, Ozcan M, Atilgan D, Yilmaz MT, Guven O. Heart rate variability in diabetes patients. J In Med Res 2006;34: 291-96.

4. Shaw JE, Sicree RA and Zimmet PZ . Global estimates of the prevalence of diabetes for 2010 and 2030.Diabetes Res Clin Pr. 2010;87(1):4-14. doi:10.1016/j.diabres.2009.10.007.

5. Dimitropoulos G, Tahrani AA, Stevens MJ. Cardiac autonomic neuropathy in patients with diabetes mellitus. World J Diabetes 2014; 5(1): 17-39. doi: 10.4239/wjd.v5.i1.17.

6. Kuehl M and Stevens MJ. Cardiovascular autonomic neuropathies as complications of diabetes mellitus. Nat Rev Endocrinol 2012;8:405-16. doi:https://doi.org/10.1038/nredo.2012.21

7. Vinik AI, Maser RE, Mitchell BD, Freeman R. Diabetic autonomic neuropathy. Diabetes Care. 2003;26 (5): 1553- 79.

8. Verrotti A, Prezioso G, Scattoni R, Chiarelli F. Autonomic neuropathy in diabetes mellitus. Front Endocrinol 2014;5: 1-5. doi: 10.3389/fendo.2014.00205.

9. Sakakibara M, Takeuchi S and Hayano J. Effects of relaxation training on cardiac parasympathetic tone. Psychophysiology. 1994;31(3):223-28. doi: 10.1111/j.1469-8986.194.tb02210.x.

10. Earnest CP, Lavie CJ, Blair SN, Church TS. HRV characteristics in sedentary postmenopausal women following 6 months of exercise training. The DREW study. PLOS one. 2008;3 (6): 2288. Doi: 10.1371/journal.pone.0002288.

11. Fatema ME, Begum N and Ferdousi S. Effect of deep relaxation on heart rate variability in sedentary females. J Bangladesh Soc Physiol 2014; 9(1): 6-10.

12. Vinutha HT, Raghvendra BR and Manjunath NK. Effect of integrated approach of yoga therapy on autonomic functions in patients with type 2 diabetes. Indian J Endo Metab. 2015 Sep-Oct; 19(5):653-57. doi: 10.4103/2230-8210.163194

13. Ross A and Thomas S. The health benefits of yoga and exercise:A Review of Comparison Studies. The J Alter Complement Med. 2010;1:6(1):3-12. doi: 10.1089/acm.2009.0044

14. Amita S, Prabhakar S, Manoj I, Harminder S, Pavan T. Effect of yoga-nidra on blood glucose level in diabetic patients. Indian J Physiol Pharmacol. 2009; 53(1): 97-01.

15. Khemka SS, Rao NH and Nagarathna R. Immediate effects of two relaxation techniques on healthy volunteers. Indian J Physiol Pharmacol. 2009; 53: 67-72.

16. Cohen DL, Wintering N, Tolles V, Townsend RR, Farrar JT, Galantino ML, Newberg AB. Cerebral blood flow effects of yoga training: Preliminary evaluation of 4 cases. J Alter Complement Med. 2009;15(1): 9-14. doi: 10.1089/acm.2008.0008.

17. Benson H, Wilcher M, Greenberg B, Huggins E, Ennis M, Zuttermeister PC, Myers P, Friedman R. Academic performance among middle school students after exposure to a relaxation response curriculum. J Res Dev Educ2000; 33(3):156-65.

18. Al-Hazimi A, Al-Ama, Syiamic Ahmad, Qosti R, and Abdel-Galil K. Time-domain analysis of heart rate variability in diabetic patients with and without autonomic neuropathy. Annals of Saudi Medicine 2002; 22 (5-6): 400-03. doi: 10.5144/0256-4947.2002.400.

19. Task Force of the European Society of Cardiology and the North American Society of pacing and electrophysiology. Heart rate variability: standards of measurement, Physiological nterpretation and clinical use. Circulation 1996; 93: 1043-65.

20. Woo MA, William G, Debra K, Holly R. Complex heart rate variability and serum norepinephrine levels in patients with advanced heart failure. J American Coll Cardiol 1994;23(3):565-69. doi: 10.1016/0735-1097(94)90737-4.

21. Malpas SC and Maling TJB. Heart-rate variability and cardiac autonomic function in diabetes. Diabetes. 1990; 39: 1177-81.

22. Schroeder EB, Chambless LE, Liao D, Prineas RJ, Evans GW, Rosamond WD, Heiss G . Diabetes, glucose, insulin, and heart rate variability. Diabetes Care. 2005;28 (3): 668-74.

23. Vempati RP and Telles S. Yoga based guided relaxation reduces sympathetic activity in subjects based on baseline levels. Psychol Rep. 2002; 90(2): 487-94.

24. Sarang PS and Telles S. Effect of two yoga based relaxation techniques on HRV. Int J Stress Manage 2006; 13 (4):460-475. doi: 10.1037/1072-5245. 13.4.460.

25. An H, Kulkarni R, Nagarathna R, Nagendra HR. Measures of HRV in women following a meditation technique. Int J Yoga. 2010; 3(1): 6-9.

26. Pushpanathan P, Trakroo M, Swaminathan RP, Madhavan C. Heart rate variability by poincare plot analysis in patients of essential hypertension and 12-week yoga therapy. Nation J Physio Pharmacy Pharmacol 2015; 5(3):174-79. Doi:10.5455/njppp.2015.5.1012201412.

27. Patra S and Telles S. Heart rate variability during sleep following the practice of cyclic meditation and supine rest. Appl Psy Physiol and Biofeedback. 2010;35(2):135-40.

28. Telles S, Raghavendra BR, Naveen KV, Manjunath NK, Kumar S, Subramanya P. Changes in autonomic variables following two meditative states described in yoga texts. J Alter Compliment Med. 2013; 19(1):35-42. Doi: 10.1089/acm.2011.0282.

29. Peng CK, Henry IC, Mietus JE, Hausdorff JM, Khalsa G, Benson H, Goldberger AL. Heart rate dynamics during three forms of meditation. Int J of Cardiol 2004; 95: 19-27.doi:10.1016/ ijcard.2003.02.006.

30. World Health Organization. Definition and diagnosis of diabetes mellitus and intermediate hyperglycemia: Report of a WHO/IDF Consultation. [Internet]. Geneva: World Health Organization; c2006. [Cited 2016 Mar 13]. Available from: https://www.idf.org.

31. Tarvainen MP, Laitinen TP, Lipponen JA, Cornforth DJ, Jelinek HF. Cardiac autonomic dysfunction in type 2 diabetes – effect of hyperglycemia and disease duration. Front Endocrinol 2014; 5: 1-9.

32. Phurpa and Ferdousi S. Diabetic cardiac autonomic dysfunction and its relationship with duration of diabetes. J Bangladesh Soc Physiol 2016;11 (1):1-5.

33. Krishna P, Rao D and Navekar VV. Cardiac Autonomic Activity in Overweight and Underweight Young Adults. Indian J Physiol Pharmacol 2013; 57(2): 146–52.

34. Khandoker AH, Jelinek HF and Palaniswami M. Indentifying diabetic patients with cardiac autonomic neuropathy by heart rate complexity analysis. Med Eng Phy 2009; 8(3): 124-130. doi:10.1186/1475-925X-8-3.

35. Mirza M and Lakshmi ANR. A comparative study of heart rate variability in diabetic subjects and normal subjects. Int J Biomed Adv Res 2012; 3(8): 640-44. doi: 10.7439/ijbar.v3i8.542.

36. Kataoka M, Ito C, Sasaki H, Yamane K, Khono N. Low heart rate variability is a risk factor for sudden cardiac death in type 2 diabetes. Diabetes Res Clin Pract 2004; 64: 51-58. doi: 10.1016/j.diabres.2 003.10.009.

37. Goit RK, Paudel BH, Sharma SK, Khadka R. Heart rate variability and vibration perception threshold in type 2 diabetes mellitus. Int J Diabet Dev Ctries 2013; 33(3): 134-39.

38. Roy B and Ghatak S. Nonlinear methods to assess changes in heart rate variability in type 2 diabetic patients. Arq Bras Cardiol 2013;101(4):317-327. doi: 10.5935/abc.20130181

39. Yesmin J, Begum N and Ferdousi S. Effect on time domain parameters of HRV after slow breathing exercise in Type 2 diabetes mellitus. J Bangladesh Soc Physio. 2017; 12(1):15-20. http://www. banglajol.info/index.php/JBSP.

40. Posner MI and Petersen SE. The attention system of the human brain. Annual Review Neurosci 1990; 13: 25-42.

41. Lazar SW, Bush G, Gollub RL, Fricchione GL, Khalsa G, Benson H. Functional brain mapping of the relaxation response and meditation. Neuro Report 2000; 11(7):1581-85.

42. Newberg AB, Iversen J. The neural basis of the complex mental task of meditation: neuro-transmitter and neurochemical considerations. Medical Hypotheses 2003; 61(2): 282-91.

43. Dooley C. The impact of meditative practices on Physiology and Neurology: A review of the literature. Scientia Discipulorum 2009;4: 35-59. http://hdl.handle.net/20.500.12648/1263.