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Original Article

Physiology Section

Effect of Yoga on Nonlinear Dynamics of Heart Rate in Prediabetic Subjects

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ABSTRACT

Introduction: Pre-diabetes represents the initial stage of type 2 diabetic disease developments. Prediabetes disease progression to overt type 2 diabetes occurs when pancreatic beta cells cannot produce insulin to overcome insulin resistance, resulting in further hyperglycaemia. Prediabetic patients have higher risk for Cardiovascular Diseases (CVDs) which further increases the rate of mortality. Lifestyle interventions such as yoga can prove to be a beneficial non pharmacologic intervention in preventing progression of prediabetes to type 2 diabetes.

Aim: Present study highlights the importance of short term intervention i.e., yoga on Heart Rate Variability (HRV) in prediabetic subjects and its use as a tool for homeostasis of Autonomic Nervous System (ANS) and primary prevention of diabetes.

Materials and Methods: This was an interventional study conducted on adults aged 30 to 50 years for analysis of frequency domain parameters i.e., Low Frequency (LF), High Frequency (HF), ratio of low frequency to high frequency of HRV. A total 102 prediabetic subjects were recruited from OPD of Jaipuria Hospital. These were divided into two groups A and B. Group A (n=51) were given intervention of set of yogic exercises and Group B (n=51) did not perform any yoga session. Statistical analysis was done by student's paired t test for intragroup comparison before applying this test the Smirnov-Kolmogorov test was conducted to confirm the normality of each parameter.

Results: Yoga intervention resulted in a significant decline in LF component and increase in HF component and LF/HF (Low Frequency/High Frequency) ratio shift sympathetic to parasympathetic dominance (p-value<0.001) in study group relative to the control group.

Conclusion: Short term yoga intervention is helpful in shifting of ANS towards the parasympathetic dominance which is assessed by frequency domain of HRV in prediabetes subjects. This preliminary study indicates that a yogic exercise change mind, body balance that facilitates autonomic balance for adults at high risk for type 2 diabetes. In addition, yoga holds promise as an approach to reducing cardiometabolic risk factors and increases exercise efficacy in prediabetics performing yoga.

Keywords: Heart rate variability, Risk factors, Type-2 diabetes mellitus

INTRODUCTION

Diabetes, the most common endocrine disorder, is projected to show a worldwide increase from 366 million people in the year 2011 to 552 million in the year 2030, out of which around 101 million are expected to be contributed from India [1]. Diabetic patients have higher risk for CVDs which further increases the rate of mortality [2].

Reason for the rate of increase of mortality may be due to lack of observation, follow-up programmes and self awareness about the conditions of disease. Moreover, the disease manifestations starts in the early stages of diabetes and before it gets established as a full blown condition it is known as prediabetes [3]. Cardiovascular disease, the most common diabetes-related morbidity, is prevalent in the pre-diabetic state even prior to the onset of overt type 2 diabetes [4]. Type 2 Diabetes Mellitus (T2DM) is commonly associated with other CVD risk factors, such as hypertension, dyslipidaemia and obesity.

Prediabetes is an intermediate stage between normal glucose tolerance and type 2 diabetes mellitus. It has been predicted that 25% of the subjects with prediabetes progress to diabetes in five years [5]. Prediabetes is considered to be a risk state, with high chances of developing diabetes [6].

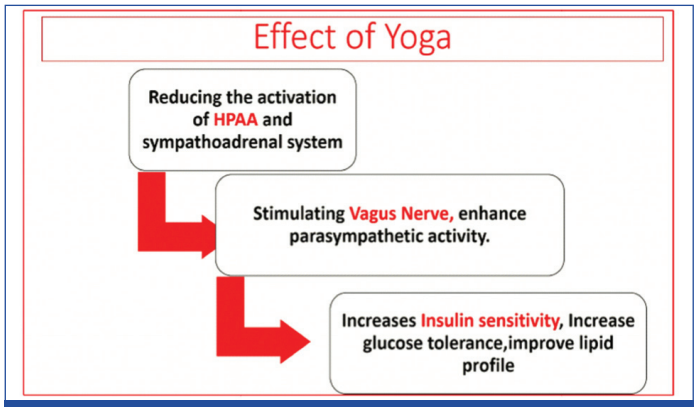
Dunstan et al., have demonstrated the presence of microvascular and macrovascular complications in prediabetecs [7]. Hyperglycaemia, insulin resistance and CVD have been associated with chronic and subclinical inflammation, as indicated by elevated circulating levels of proinflammatory proteins [8].

The specific cause of endothelial dysfunction in early atherosclerosis including circulating derivatives of cigarette smoking, hyperglycaemia, insulin resistance and CVD have been associated with chronic and subclinical inflammation as indicated by elevated circulating levels of proinflammatory proteins.

The ANS plays vital part in physiological as well as in pathological settings for instance diabetic neuropathy, Myocardial Infarction (MI) and Congestive Heart Failure (CHF) [9]. The cardiovascular system is regulated by multiple mechanisms, including nervous and hormonal pathways. The two divisions of the ANS, the parasympathetic, via vagus nerves, and the sympathetic system, including the adrenal medulla, play a major role in the control of cardiovascular system [10]. Autonomic dysfunction associated with increased sympathetic activity and reduced parasympathetic activity and profound sympathetic activity implicated in the pathophysiology of arrhythma and sudden cardiac death [10]. A dysregulation in the autonomic nervous control of the cardiovascular system associating increased sympathetic and reduced parasympathetic tone plays an important role in coronary artery disease and in the genesis of life threatening ventricular arrhythmia [11]. Among the different available techniques for assessing the two limbs of ANS Heart Rate Variability (HRV) become a popular noninvasive method to evaluate the autonomic balance at the sinoatrial level. Major applicability of HRV to assess ANS in a variety of clinical situations such as diabetic neuropathy, MI, sudden death and CHF [10]. Altered Cardiac Autonomic Function (CAF) assessed using HRV is associated with metabolic abnormalities including obesity, prediabetes and diabetes. HRV is the change in the time interval between heartbeats [12]. It is controlled by the ANS, which also controls many other vital functions of the body [13]. HRV is indicator of autonomic regulation and used as a representation for health and fitness, therefore, appears to evaluate the variations occurring with mind body practices that enable

autonomic balance [14]. HRV is an index of vagal tone and reflects the balance between parasympathetic and sympathetic system [15]. Analysis of HRV comprises of a sequence of measurements of successive Interbeat (RR) interval variations of sinus origin which offer information about autonomic tone [16]. In 1996 a Task Force of the European Society of Cardiology (ESC) and the North American Society of Pacing and Electrophysiology (NASPE) defined and established standards of measurement, physiological interpretation and clinical use of HRV [17]. Time domain indices, geometric measures [18] and frequency domain indices [19] constitute the standard clinically used parameters. Frequency domain analysis which defines the periodic oscillations of the HR signal disintegrated at diverse frequencies and amplitudes and offers information on the amount of their relative intensity named as variance or power in the heart's sinus rhythm [20]. Yoga exercises restore internal balance and homeostasis of the body by influencing every organ system. In the human body, there are some glandular structures which have both an internal as well as an external secretion. The best example is the pancreas which secretes insulin. The Yogic therapeutics helps in restoring the internal secretions to their normal value by securing the health of all the endocrine organs [21]. Yogic exercises are now, one of the non-pharmacological therapies against stress and have shown to be effective in improving stress depression, blood level of cortisol with decrease in sympathetic activity [22].

[Table/Fig-1] represent effect of yoga on reducing the activation of Hypothalamic Pituitary Adrenal Axis (HPAA) which stimulates vagus nerve that enhance parasympathetic activity which increase insulin sensitivity, increase glucose tolerance and improve lipid profile.



[Table/Fig-1]: Flow diagram of mechanism of action of yoga.

In this present study intervention was done by Integrated Approach of Yoga Therapy (IAYT), which includes lectures on yoga (concept of yoga, streams of yoga and basis of yoga therapy), prayer, omkar recitation, practice of yoga postures (asana), regulated breathing (pranayama) and lectures on yoga [23]. To compare the previous studies there are no such type of study available on effect of yoga on HRV in prediabetic subject so this study help in data collection and to know effect of yoga on HRV in prediabetic subjects.

The aim of this study was to assess the effect of IAYT on frequency domain parameter of HRV.

MATERIALS AND METHODS

This was a Quasi prospective comparative study among adults aged 30 to 50 years, this age group was chosen for two reasons. First the subjects were prediabetics, and second, autonomic dysfunctions are affected by ageing in RUHS college of Medical Sciences and Associated Rukmani Devi Beni Prasad Jaipuria in Jaipur city. Written informed consent was taken from the participants in the local language and the study was approved by: Institutional ethics committee (Registration No.ECR/762/) of the RUHS College of Medical Sciences. In the tertiary health care centre a total of 1000 participants were screened out of which 125 were prediabetic. Prevalence of prediabetic subjects was 12.5%. Study was conducted from August to December 2017. The information collection proforma contained details about the age, sex, family history, socio-demographic, lifestyle, physical activity; Stress scale by cohen perceived scale, Body Mass Index (BMI), dietary habits by semi-quantitative Food Frequency Questionnaire (FFQ) and personal history medical factors. Data collected by an interviewed questionnaire, anthropometric measurements and laboratory investigation. Base line parameters like anthropometic, blood pressure, pulse and HRV, Frequency domain LF, HF and LF/HF ratio and Detrended Fluctuation Analysis (DFA) suitable for the analysis of nonstationary time series, has confirmed the existence of persistent long-range correlations in healthy HRV. Data were recorded by Analogue Digital Instrument (AD), physiograph (Model number 3818). DFA derived from a modified root mean square analysis of a random walk. It is a method for determining the statistical self-affinity of a signal and also useful for analysing time scales from the fluctuations of the multi-component systems and analysis of biological data.

Sample size of present study was 102 calculated by using the prevalence of prediabetes in India as 8% [24]. The sample size n is calculated by using the formula z^2pq/d^2 where p and q were taken as 0.05 and 0.95 respectively to get the maximum sample size with 5% permissible error (precision) and 10% non response rate hence the derived sample size is 102 with 95% confidence interval.

Participants should fulfill the inclusion criteria i.e., fasting blood glucose level of: 110 to 125 mg/dL (6.1 mM/L to 6.9 mM/L) and glycated haemoglobin 5.7 to 6.4 (WHO criteria) [25-27] and subjects having no history of CVD in subject or in first-degree relatives, and should not be on drugs which affect blood sugar levels. Exclusion criteria was subjects with fasting blood glucose <100 mg/dL and >126 mg/dL, Oral Glucose Tolerance Test (OGTT) <140 and >200 mg/dL [25,26], liver disease, alcoholic individuals, renal dysfunction, diabetic retinopathy and neuropathy, spinal injury and interstitial fibrotic disease or any other major complications. Those being treated with anti-inflammatory medication were not included in the study [Table/Fig-2].

S. No	Variable	Prediabetes
1	Age=30 to 50 years	125
2	Female gender	75
3	Family history of diabetes	65
4	BMI >25	89
5	Central obesity	101
6	Physical inactivity	100
7	Psychosocial stress	100
8	Vegetables <2 servings a day	100
9	Red meat, chicken, fish and egg > once time a week	20
10	Fruit < one time in a week	76
11	Green leafy vegetable <3 times a day	89
12	Bakery Items > once time a week	30
13	Deep fried snacks	36
14	Carbonated drinks > once a week	11
15	Sweet >3 time a week	40
16	Tobacco use	20
17	Alcohol use	30

[Table/Fig-2]: Possible risk factors for prediabetes.

HRV is determined from either 5-minute or 24-hour recordings of the electrocardiogram, or ECG. The consecutive beat-to-beat intervals (R-R intervals) are extracted from the ECG. HRV software packages automate this process in a variety of ways. In order to simplify the recording of a signal for analysis in this experiment, the peripheral pulse is used rather than the ECG. Given that every normal cardiac cycle will result in a peripheral pulse, the peak-to-peak interval of the pulse is equivalent to the R-R interval from an ECG recording.

Procedure: PowerLab is turned on and the USB cable is connected to the computer. Connect the Finger Pulse Transducer on the front panel of the PowerLab. Place the electrodes and pressure pad of the Finger Pulse Transducer. Analysis of HRV in the frequency domain gives information about the speed of variation in heart rate. This technique involves analysing and displaying the various frequency components of the N-N intervals and their power, or variance.

Required Equipments

- LabChart Software
- PowerLab Data Acquisition Unit
- Finger Pulse Transducer

[Table/Fig-3] showed that base line parameters like body mass index, waist hip ratio, blood pressure systolic and diastolic and pulse rate before and after yoga and results were in reference to p-value significant.

S. No.	Base line parameters	Control Pre	Control Post	Yoga Pre	Yoga Post	p-value
1.	BMI	28.6±3	28.7±2	27.8±7	26.8±4	<0.001
2.	Waist hip ratio	90±6	92±6	91±7	85±4	<0.05
3.	Blood pressure SBP	152±8.3	153±8.4	154±7.3	130.7±10.1	<0.002
	DBP	90.8±4.2	90.7±4.3	92.8±4.2	88.3±3.9	<0.001
4.	Pulse rate	90.2±9.8	90.1±8.8	89.2±9.7	82±8 6	<0.05

[Table/Fig-3]: Base line parameters before and after yoga.

Study group, (n=51) was engaged in lectures on yoga, prayer, omkar recitation, practice of yoga postures (asana), regulated breathing (pranayama) and control group (n=51) did not perform any sessions.

Analogue Digital Physiograph

Analogue digital physiograph instrument is an eight channel digital physiograph for assessing HRV, electrocardiogram, galvanic skin resistance, reaction time and hand grip dynamometery. In the present study HRV was measured by frequency domain analysis which describes the periodic oscillations of the HR signal decomposed at different frequencies and amplitudes and provides information on the amount of their relative intensity termed as variance or power in the heart's sinus rhythm [19]. Power spectral analysis can be performed by two ways: 1) Fast Fourier Transformation (FFT), which is characterised by discrete peaks for the several frequency components; and 2) Autoregressive model estimation resulting in a continuous smooth spectrum of activity. When using the FFT the individual RR intervals are transformed into bands with different spectral frequencies. The power spectrum consists of frequency bands ranging from 0 to 0.5 Hz and can be classified into four bands: the Ultra Low Frequency band (ULF), the Very Low Frequency band (VLF), the Low Frequency band (LF) and the High Frequency band (HF) [18].

The IAYT included prayer, omkar recitation, yoga postures (asanas), breathing (pranayama) techniques, shavasana, counselling and diet i.e., food that are considered sattivic include most vegetables, ghee, fruits, legumes and whole grain). Yoga was used as an interventional therapy in this study. Yoga asans were guided and demonstrated by certified yoga instructor. Yoga sessions were approximately 45 minutes six days in a week over a period of three months. To facilitate and guide home practice, participants were given a video recording (CD) of the IAYT recorded under direction of the certified yoga instructor and session in morning 7 to 7.45 AM, compliance of patients were checked by message daily and weekly telephonic conversions. Evaluation was done before yoga intervention then after three months post intervention. The components of our intervention using IAYT are detailed in [Table/Fig-4] [28].

S. No.	Yogic practices	Duration
1	Prayer	3 minutes
2	Omkar recitation	3 minutes
3	Pranayama	5 minutes
4	• Asans (SuryaNamaskar, Sukhasana, Bhujangasana, Pashimottanasana, Padmasana, Tadasana, Trikonasana, Sarvangasana, Ardhmatsyendrasana, Pawanmuktasana, Vajrasana, Dhanurasana)	30 minutes
	• Shavasana	5 minutes

[Table/Fig-4]: Schedule of yoga practices [28].

[Table/Fig-4] show the protocol of yoga practices in this study, in this protocol a cycle of 46 minutes that included prayer, omkar recitation, pranayama different asans and posture that included SuryaNamaskar, Sukhasana, Bhujangasana, Pashimottanasana, Padmasana, Tadasana, Trikonasana, Sarvangasana, Ardhmatsyendrasana, Pawanmuktasana, Vajrasana, Dhanurasana, shavasana.

STATISTICAL ANALYSIS

Mean and standard deviations are calculated for each parameter. The appropriate tool for comparison of the change in the level of a variable is student's paired t-test for intragroup comparison before applying this test the Smirnov-Kolmogorov test is conducted to confirm the normality of each parameter. For all the variables normality is confirmed. The level of significance is taken at 5%. Tables are constructed to show mean and standard deviation for the various parameters. Inference of significance is drawn on the value of p. Apart from comparing the various parameters of the data with respect to before and after yoga, comparison is made with respect to a control group. There are 51 persons in this group. To show that initially the two groups are on the same platform for each parameter, student's unpaired t-test is conducted for intergroup comparison. If the value of p is more than 5%, for any parameter, that shows there is no significant difference between the two groups.

RESULTS

All the parameters of the data are quantitative variables. The main purpose of the study is to compare the levels of these parameters before initiating IAYT and after three months of practicing IAYT. Apart from comparing the various parameters of the data with respect to before and after yoga, comparison is made with respect to a control group. There are 51 prediabetics subjects in both the groups.

Nonlinear method such as DFA was proposed and proved to be useful for the possible non-stationary and nonlinear characteristics in the time series of heart period [29].

DFA method was developed from a modified root mean square analysis of a random walk to exclude the local trend induced by characteristic time scales from the fluctuations of the multi-component systems, and get a long-range correlation [30,31].

The [Table/Fig-5] shows the mean values for the five entropic measures for control and yoga group subjects RR intervals. The number of RR intervals is 256. ANOVA1 and Kruskal-Wallis tests of significance were applied to results. Notice here the DFA is included with the five measures of entropy as a benchmark. [Table/Fig-6] shows mean values of LF, HF, LF/HF Ratio for control and study groups. Intergroup comparison of results of HRV in control and study groups, unpaired t-test applied to results. Results are significant (p-value<0.0001) in study groups as compared to control group. [Table/Fig-7] shows intergroup comparison of LF, HF, LF/HF ratio for control and study groups.

Entropy type and DFA	Mean±SD control	Mean±SD Yoga group	ANOVA1	Kruskal-Wallis	Cohen's	Effect size
Approximate	0.8020±0.131	0.7677±0.134	0.0316	0.0231	0.72	Medium
Sample	0.7135±0.147	0.7426±0.144	0.6572	0.5963	0.14	Large
DFA	0.3849±0.265	0.6454±0.201	0.0004	0.0004	1.24	Small
Shannon	0.7642±0.126	0.7542±0.123	0.7044	0.6387	0.17	Small
Renyi	0.9914±0.005	0.9911±0.005	0.6665	0.6517	0.17	Small
Tsallis	0.7881±0.114	0.7697±0.111	0.5873	0.6517	0.16	Small

[Table/Fig-5]: Detrended fluctuation analysis.

Parameters		Pre	Post	p-value
		Mean±SD	Mean±SD	
LF	Control	65.72±11.44	67.82±12.44	0.876
	Study	66.67±11.87	45.67±13.9	<0.001
HF	Control	35.90±11.79	36.85±12.08	0.689
	Study	36.40±11.75	51.56±13.06	<0.0001
LF/HF Ratio	Control	2.18±1.09	2.20±1.05	0.8862
	Study	2.19±1.09	1.010±0.54	<0.0001

[Table/Fig-6]: Intragroup comparison of results of heart rate variability.
p-value<0.001 Highly significant

Parameters	Control	Study Group	p-value
	Mean±SD	Mean±SD	
LF	67.82±12.44	45.67±13.9	<0.0001
HF	36.85±11.75	51.56±13.06	<0.0001
LF/HF	2.20±1.05	1.01±.54	<0.0001

[Table/Fig-7]: Intergroup comparison of results of heart rate variability.
p-value<0.001, Highly Significant

DISCUSSION

The results of this study showed importance of yoga intervention for increasing parasympathetic tone and reducing sympathetic tone. The present study indicates that a yoga program would be a possible risk reduction option for prediabetic. Regular yoga practices help in reducing cardiovascular risk factors and improve homeostasis at the neuroendocrinal level which increases exercise self-efficacy for prediabetics that perform yoga.

Yoga practices appear to improve autonomic regulation and enhance vagal dominance as reflected by HRV measures. Changes in HRV with yoga may reflect resonance effects between respiration, muscle contractions, HR, and baroreflexes that enhance autonomic efficiency.

The two divisions of the ANS, the parasympathetic, via vagus nerves, and the sympathetic system, including the adrenal medulla, play a major role in the control of cardiovascular system. HRV is the change in the time interval between heartbeats.

The regular practice of yoga is known to elevate mood and relieve the stress by increasing serotonin levels. Regular practice of yoga increases tissue oxygenation, oxygen saturation and blood flow, reduces viscosity of the blood which can decrease in heart attack and strokes [32].

Lifestyle Modification (LSM) from a promising view that considered to be the first line of intervention prior to any drug therapy for preventing the progression of prediabetes to diabetes. Lifestyle modification is the most effective, cheaper and safer approach to type 2 diabetes prevention [32]. The effect of yoga on different parameters i.e., decreased BMI, waist hip ratio and blood pressure, these finding correlated with the findings of Gadham J et al., [33].

Devasena I et al., reported that significant reduction in the heart rate occurs in the subjects practicing yoga ($p<0.001$). The systolic and diastolic blood pressure was dropped to a highly significant level ($p<0.001$). This demonstrates that yoga delivers significant improvement in ageing to decrease the morbidity and mortality from cardiovascular diseases [34].

A studies by Birkel DA et al., Bharshankar JR et al., reported that during exercise there is improved oxygen uptake and utilisation, increased endurance and decrease heart rate [35,36].

Practice of yoga helps achieve emotional balance, inhibits the areas in amygdala responsible for fear, aggression and rage. It stimulates the reward or pleasure centres in the median forebrain and other areas leading to a state of bliss and pleasure. This in turn lowers anxiety, respiratory rate, heart rate, and blood pressure [37,38]. Autonomic balance is the body's ability to maintain equilibrium (stability and balance) during internal and external stimuli. This system plays a major role in bringing about adaptation of human body to environmental changes, thereby modulating the sensory, visceral, motor and neuroendocrine functions regulate the activity of all muscles and certain glands [39].

Sympathetic nervous system overactivity in the form of profound hyperglycaemia in response to epinephrine along with high levels of endogenous opioid peptides is also found to be an etiological factor in type II diabetes [40-42].

HRV has emerged as a simple, noninvasive method to evaluate the sympathovagal balance at the sinoatrial level for assessing the autonomic status, health and fitness and therefore, appears well placed to assess the changes occurring with mind-body practices [43]. HRV measured by using the intervals between QRS complexes of normal sinus depolarisations [44].

In this present study LF component and LF/HF ratio decreased and HF component increased as compared to control which was similar with Sarang SP et al., who reported that Cyclic Meditation (CM) have suggested that sympathetic activation occurs predominantly during the yoga posture phases following CM, the parasympathetic nervous system becomes dominant [44]. Vempati RP et al., reported that 10 minute yoga intervention decreased LF, Increased HF and decreased LF/HF ratio as compare to control group which was similar with the present study [40]. An H et al., reported that nonlinear measure was the sampling entropy i.e., increase in the meditative group as compared to the control group [41]. Further laboratory studies Howorka K et al., Pitale R et al., Muralikrishnan K et al., reported that yoga practitioners showed well-balanced beneficial activity of vagal efferents, and sympathovagal balance compared to non-yoga practitioners these results were similar with present study [42,45,46]. Previous studies by Friis AM et al., reported that long-term yoga practice could be beneficial in terms of autonomic flexibility [47]. Satin JR et al., reported that yogis and runners enhanced parasympathetic activity measured in the time and/or frequency domain [48] which was similar with present study on contrary study by Chaya MS et al., reported that yoga group had significantly higher low-frequency power and lower normalised high-frequency power [49].

LIMITATION

The findings of this study need to be explored in larger trials involving prediabetics. Further research is also necessary to determine the long-term effect of yoga practice on HRV among individuals with or at risk for prediabetes to clarify the influence of yoga on a autonomic homeostasis associated with prediabetes. In this study only one component of HRV i.e., frequency domain analysed other components time domain, poincaré plot and histogram should be done on larger sample.

CONCLUSION

This study highlights the importance of yoga intervention which was effective in increasing parasympathetic tone and reducing sympathetic tone. This preliminary study indicates that a yoga program would be a possible risk reduction option for adults at high risk for type 2 diabetes. In addition, yoga programs would be an approach to reduce cardiovascular risk factors and increasing efficacy of exercise in prediabetic group that perform yoga.

Yoga practices appear to improve autonomic regulation and enhance vagal dominance as reflected by HRV measures. In yoga group increased autonomic efficiency which reflects by resonance between respiration muscle contraction, heart rate and baroreflex. Moreover, additional research with a larger sample and a longer follow-up required to elucidate the autonomic and clinical benefits of such practices.

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ANNEXURE 1: PRE-DIABETES QUESTIONNAIRE

1	Name					
2	Age					
3	Sex					
4	Height					
5	Weight					
6	Body mass index					
7	Occupation					
8	Phone number					
9	E mail					
10	Have you had previous prediabetes education?	Yes		No		
	If yes, where?					
11	How would you rate your understanding of pre-diabetes?	Very Good	Good	Fair	Poor	
12	Do you have any food or drug allergies?	Yes		No		
	If yes, please explain:					
13	Do you smoke?	Yes		No		
	If yes, how much?					
14	Do you drink alcohol?	Daily	Weekly	Monthly	Rarely	Never
15	What do you drink and how many drinks do you have?					
16	Do you currently have, or have you ever had?	Chest pain	High blood pressure	Neuropathy	Kidney disease	
17	How often do you see your pre-diabetes physician? Date of last visit:					
18	Do you perform a daily foot exam?					
	If yes, when and why?					
19	How often do you have a dental checkup?					
20	Have you ever had an ECG or cardiac stress test?					
	If yes, what were the results?					
21	Has your weight changed over the past year?					
	If yes, please describe:					
22	Have you ever been on an extreme diet or fad diet?					
	If yes, please describe:					
23	Diabetes history When were you diagnosed with pre-diabetes?					
24	List blood relatives with diabetes.					
	Diabetes Questions and Knowledge:					
25	Have you received diabetes education before?					
	If yes, when and where					
26	How would you rate your understanding of diabetes?	Very good	Good	Fair	Poor	
27	What is your biggest concern related to diabetes?					
28	Are there any religious or cultural concerns you have relating to your diabetes?					
	If yes, what					
	Blood Sugar Monitoring:					
29	Do you test your blood sugar?					
	If yes, when and how often?					
30	Do you record your blood sugars?					

	Physical Activity				
31	What best describes your daily physical activity	Mild	Moderate	Severe	
32	Do you follow a regular exercise program or not?				
	If yes, what type of exercise do you do?				
33	How many days per week do you exercise?				
34	What time of day do you usually exercise?				
	Stress Management and Support				
35	How does stress affect you physically or emotionally?	Sleeping difficulties	Depression	Eating too much/too little	Headaches
36	Is there stress in your life?				
37	If yes, what is the source of stress?				
38	How do you deal with stress?				
39	Are family or significant others supportive of your pre-diabetes considerations?				
	Nutrition				
40	What nutrition information would you like to learn more about?	Weight management		Nutrition strategies to control blood sugar	
41	Do you have any specific nutrition questions you would like answered?				
42	How often does your eating habits leave you feeling deprived?	Always	Often	Sometimes	Never
	Please explain				
43	How many times a week do you eat away from home?				
44	What type of restaurants do you usually eat or carry out?				
45	Do you ever skip meals?				
46	How many meals do you usually eat per day?				
47	How many snacks to you usually eat per day?				
48	Do you get up during the night to eat or drink (other than water)?				
	If yes, what?				
49	Do you eat for reasons other than hunger?				
	If yes, please describe:				
50	Do you have trigger foods that often cause you to overeat?				
	If yes, what foods?				
51	How often to you use nutrition strategies to control your blood sugar or for other health reasons?				
52	Please write samples of your usual food and beverage intake and the times you eat your meals or snacks				

Breakfast	Lunch	Dinner	Snacks

53	Medication list	
54	Signature	