Original Article

Correlation of Heart Rate Variability with Carotid Intima Media Thickness after 6 Month of Yoga Intervention in Prediabetics

Abstract

Introduction: Atherosclerotic carotid intimamedia thickness (CIMT) may be associated with alterations in the autonomic functions. The aim of this study was to investigate the effect of 6-month yoga intervention on heart rate variability (HRV) and CIMT in elderly subjects and the correlation between HRV and CIMT. **Methodology:** This was a randomized controlled study, in which a total of 250 subjects were enrolled. Randomization and allocation in yoga and control groups were performed using computer-generated random numbers. The CIMT was determined by B-mode ultrasonography, and cardiac autonomic function was determined through frequency domain parameter of HRV measures at baseline and after 6 months of yoga intervention. **Results:** Participants had a mean age of 45.4 ± 6.4 years, and a mean CIMT in control (0.70 ± 0.05) and study group (0.69 ± 0.073), and low frequency/high frequency (LF/HF) ratio in control (2.20 ± 1.05) and study group (0.57 ± 0.54). Yoga group had evidence of increased vagal activity in the frequency domain (HF and LF/HF ratio, $P < 0.001$) with respect to control group. Moreover, a study group showed lower intimamedia thickness (IMT) than control subjects ($P < 0.01$). In the whole population, LF/HF ratio positively and significantly correlated ($r = 0.665$, $P < 0.01$) to IMT. **Conclusion:** This study demonstrated that, after yoga intervention, LF/HF ratio is positively correlated with CIMT, a putative index of atherosclerosis, confirming cardiac autonomic neuropathy as a part of the pathophysiological pathway for atherosclerosis. It confirms that the regular yoga represents a valuable strategy to counter impairments of cardiac autonomic activity and artery structural changes.

Keywords: *Carotid intima media thickness, heart rate variability, yoga*

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Introduction

Prediabetes is a state between normoglycemia and diabetes with "impaired fasting glucose (IFG) and impaired glucose intolerance (IGT)" that also indicate an increased risk of cardiovascular disease and development of Type 2 diabetes in future.[1] However, IFG and IGT both presented with "insulin resistance and insulin deficiency." Insulin secretion in these two conditions demonstrates few alterations but both are associated to cardiovascular disease.[2,3] Positive correlation exists between cardiovascular events and IGT and such relationship is not strong in IFG.[4]

Heart rate variability (HRV) was measured by electrocardiogram (ECG) that was most widely used methods for the estimation of cardiac autonomic functions.[4,5] HRV defined as the distinction in period interlude among two consecutive heart beats and it is noninvasive assessment of sympathetic and parasympathetic limbs of the autonomic nervous system.[4]

Cardiovascular autonomic dysfunction caused by destruction of nerves and vessels that innervate heart and can cause cardiovascular dysfunction and vascular dynamics abnormality. Cardiovascular autonomic dysfunction was a common complication of diabetes mellitus presented with arrhythmia, myocardial infarction, and sudden death.[5,6] Symptoms of autonomic dysfunction include sinus tachycardia, exercise intolerance, myocardial ischemia, and orthostatic hypotension. One of earliest markers of cardiac autonomic dysfunction is a reduction in HRV with parasympathetic loss that precedes sympathetic dysfunction.

Previous studies led to the hypothesis that structural and functional mechanisms in large arteries contribute to decreased baroreflex sensitivity and autonomic

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dysfunction, atherosclerosis, and aging.[7] Structural mechanisms that lead to the atherosclerosis-induced reduction in baroreflex sensitivity include structural and functional changes in the vessel wall such as fibrosis with increased vascular stiffness and distensibility.[8] In the atherosclerotic carotid sinus, fibrotic autonomic ganglia and damaged nerve endings are observed in plaques.[9] Baroreceptors are situated in the carotid bulb adventitia, due to the presence of atherosclerotic plaques decreased stretch may reduce the baroreflex sensitivity. Carotid sinus baroreceptor dysfunction may occur due to release of prostacyclin, nitric oxide, and endothelin[7] by the vascular endothelium or the accumulation of oxygen-derived free radicals[10] may occur, leading to alterations in the cardiac autonomic function.[8,9]

Lifestyle interventions such as yoga an ancient practice that is said to benefit all components of health, may prove to be helpful as nonpharmacological interventions in stopping progression of prediabetes to Type 2 diabetes and related complications.[11] The word yoga is derived from Sanskrit word Yuj means union of mind, body, and soul. Good health as a result of yogic practices can be the result of positive thinking and actions.

Yoga is an ancient discipline constituted to bring homeostasis with union of mental, emotional, physical, and spiritual dimensions of person. Yoga addresses all aspect of the human system including the mind, body emotions, breathing patterns, and relationships.[12,13] Daily practice of postures and breathing practices improves mental and physical awareness, which is need diabetes are measured by assessing HRV.[14] Through the common practice of asanas and pranayama was shown to significant shift in autonomic nervous system toward parasympathetic dominance.

Yoga plays an important role in decreasing stress, reducing sympathetic activity, increasing parasympathetic activity, reducing blood pressure (BP), improving sense of well-being, and reducing anxiety levels.[15,16]

Kuppusamy *et al*.[17] Meshram and Meshram[18] observed in a yoga intervention study over a period of 6 months that post yoga intervention, significant decreased in low-frequency (LF) and LF/high frequency (HF) ratio and significant increase in HF component of frequency domain parameters. Further studies by Vempati and Telles,[15] Pitale *et al*.,[19] Muralikrishnan *et al*.,[20] Friis and Sollers Iii,[21] and Satin *et al*.[22] reported that yoga practitioners showed marked beneficial vagal efferent activity and sympathovagal balance when compared to control group these results are similar with the present study.

Therefore, this study was designed to study the effect of therapeutic approach of 6-month yoga intervention on HRV and correlate it with carotid intima media thickness (CIMT) in prediabetes. Early diagnosis of altered cardiac autonomic functions and arterial stiffness can lead to effective strategy for the treatment of prediabetic conditions and reduce cardiovascular risk; hence, it was hypothesized that indices of HRV analysis are independently associated with carotid atherosclerotic intima-media thickness (IMT).

Methodology

Randomized controlled study was conducted in the Department of Physiology and Medicine at RUHS College of Medical Sciences and Associated Hospitals. Assessments were made before the intervention and after 6 months of integrated approach of yoga therapy (IAYT). Total duration of study was 1 year. After screening of 2000 participants, a total of 250 prediabetic participants from Outpatient Department of RUHS College of Medical Sciences and Associated Hospitals and from different yoga centers were recruited. Study (yoga) group (Group A, n = 125) was involved in IAYT. Control group (Group B, n = 125) was not involved in any specific activity that were IAYT in which constitutes prayer, omkar recitation, different asanas, breathing practices (pranayama), shavasana, counseling, and diet.

Randomization and allocation in yoga and control groups were performed using computer-generated random numbers.

Sample size was calculated as the prevalence of prediabetes in India is 8% taking it as a reference;[3] the sample size is estimated using the appropriate size formula $n = z^2pq/d^2$, n denotes the sample size, Z represents the statistic corresponding to level of confidence, p is anticipated prevalence, q is $(1 - p)$. Where p and q were taken as 0.08 and. 92 to get the maximum sample size with 5% permissible error (precision) and 10% nonresponse rate, the desired sample size is 125 with 95% confidence interval.

Age group of participant's was in range of 30–50 years that have fasting blood glucose level of 110–125 mg/dl (6.1 mM/L to 6.9 mM/L) and glycated hemoglobin levels according to ADA criteria 5.7%–6.4%. No family and personal history of cardiovascular disease and serious illness that required admission to hospital were included. Abnormal liver function test (alanine aminotransferase or aspartate aminotransferase >2.5-fold the upper normal limit), alcoholic individuals (weekly alcohol consumption >140 g), renal dysfunction, diabetic retinopathy, and neuropathy were excluded.

After obtained ethical clearance (EC/P/01/2016) by the institutional ethical committee, participants satisfying the inclusion criteria were included in the study. IAYT, purpose, and significance of the study were explained to the subjects. Detailed history in the prescribed pro forma was taken from the informant, and thorough cardiac examination was performed before the study. Various anthropometric parameters such as weight, height, body mass index, and waist hip ratio were measured as well as clinical parameters such as BP, pulse, and ECG were recorded for both groups with the help of a Digital Physiograph (Model: AD Instrument). A final set of three-step yoga program was obtained which further needs to be tested in standardized randomized controlled trials. In step first, the yoga protocol for prediabetes was developed by after reviewing eighty research publications and yoga texts on PubMed/Medline, ProQuest, PsycINFO, IndMED, and Central, Cochrane library published in the past 20 years. In second stage, preparing a yoga protocol and in third stage validation of the yoga program, a mixed methods approach integrating qualitative and quantitative inputs was considered. Quantitative as well as qualitative inputs were taken from the ten certified yoga experts after obtaining their written informed consent. The inductive method of qualitative research inclusive of the "Delphi method" (Hsu and Sandford 2007) was followed for qualitative inputs that were about the appropriateness of yogic practice, duration of each session, yoga training, sequence of yoga practices, and overall yoga protocol were collected in the form of questionnaire. Quantitative inputs were in the form of ranking provided to the yoga protocol for each practice for usefulness on a scale of 1–5 (1 – indicating not at all useful, 2 – a little useful, 3 – moderately useful, 4 – very useful, and 5 – extremely useful. In this study, we were approached ten yoga experts for the content validity, 0.48 was considered as the minimum content validity ratio (CVR = [ne − N/2]/N/2 – where ne is the number of experts indicating a practice "useful" and N is the total number of experts, 10) for retaining a particular yoga practice in the program The content analysis of the qualitative data, conducted with ATLAS. ti 5, Scientific Software Development GmbH, Lietzenburger Str. 75,10719 Berlin, Deutschland - Germany.

Table 1 depicts CVR; CVR 0.48 was considered as the minimum CVR for retaining a particular yoga practice in the program yoga asanas that had CVR >0.48 were retained in yoga protocol if yoga asanas had CVR <0.48 were omitted.

The IAYT constitutes prayer, omkar recitation, different asanas, breathing practices (pranayama), shavasana, counseling, and diet were also be part of the program. Yoga applied as interventional approach in this study. All the yoga sessions were group sessions. Entire yoga asanas and posture were explained and demonstrated by certified yoga instructor, at yoga lab and different yoga centers (Yog sadhna center-1, Yog sadhna center-2, and Patanjali yoga center). These yoga sessions' duration was last for approximately 46 min 6 day in a week over a period of 6 months and monitored by research staff. To facilitate and guide home practices all the study participants were provided images and lists of the yoga sequences ,CD and video recording and who was unable to attend yoga sessions at yoga centers performed yoga asanas and pranayama at home by help of CD and video recording which were monitored by the principal investigator and research staff to ensure consistency. Compliance was checked by attendance register of yoga centers, daily message, and weekly telephonic conversation with subject and family members. No adverse effect of yoga asanas and pranayama was explained to subjects and written in participant information sheet and written informed consent were obtained by subjects. Evaluation of HRV, biochemical parameters, and CIMT was done before yoga intervention then after 6 months postintervention.

Schedule of yoga practices

Table 2 depicts yoga protocol that includes prayer, omkar recitation, pranayama, postures, and asanas, i.e. Surya Namaskar Sukhasana, Bhujangasana, Pashimottanasana, Padmasana, Tadasana, Trikonasana, Sarvangasana, Ardhmatsyendrasana, Pawanmuktasana, Vajrasana, Dhanurasana, and Shavasans.

The subjects were encouraged and motivated to do the all yoga pose as accurately as possible. Subjects were free at the end of each yoga session, with 5 min of shavasana followed by meditation designed for relaxation.

Table 1: Content validity ratio of yoga practices for validation

Yogic practices	CVR
Prayer	0.80
Omkar recitation	0.65
Pranayama	0.77
Postures (*asanas*)	Below mentioned
SuryaNamaskar	0.89
Sukhasana	0.60
Bhujangasana	0.76
Pashimottanasana	0.67
Padmasana	0.66
Tadasana	0.55
Trikonasana	0.70
Sarvangasana	0.58
Ardhmatsyendrasana	0.70
Pawanmuktasana	0.66
Vajrasana	0.70
Dhanurasana	0.76
Shavasana	0.88

CVR=Content validity ratio

Table 2: Yoga protocol

Yogic practices	Duration (min)
Prayer	3
Omkar recitation	3
Pranayama	5
Various postures (asanas) (*SuryaNamaskar, Sukhasana, Bhujangasana, Pashimottanasana, Padmasana, Tadasana, Trikonasana, Sarvangasana, Ardhmatsyendr asana, Pawanmuktasana, Vajrasana, Dhanurasana*)	30
Shavasana	5

Heart rate variability

ECG was recorded with the help of a Digital Physiograph (Model: AD Instruments), using a standard bipolar limb lead configuration. Frequency domain analysis of HRV data was carried out. "HRV analysis software (version 1.1, Biomedical Signal Analysis team, University of Kuopio, Finland)" assesses frequency components using Fourier rapid transformation. The results of the frequency spectrum analysis were given as spectral strength at ms^2 included, very LF (0.003 Hz to 0.04 Hz), LF (LF; 0.04 Hz to 0.15 Hz), and HF (HF; 0.15 Hz to 0.4 Hz)."

Heart rate variability parameters

- Frequency Domain Measurements
  - LF power
  - HF power
  - LF power/HF power ratio.

HRV parameters were assessed using Digital physiograph (-Model AD Instruments).

CIMT: CIMT measurement was carried out on posterior wall of carotid arteries by B mode ultrasound through Acuson Sequoia ultrasonography device adjusted by eight mHz liner probe.

Results

All the parameters of the data are quantitative. The objectives of this study were to assess effect of IAYT on HRV and correlate it with CIMT in prediabetes.

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 125 prediabetics subjects in both the groups. Randomization and allocation in yoga and control groups were performed using computer-generated random numbers.

Figure 1 shows the study flow chart in this total 2000 participants were screened was 2000, out of 2000 subjects, 250 were prediabetic, and prevalence rate was 12.5%. Eligible 250 subjects were divided by computer-generated methods in control and study group. Study group was involved in IAYT over a period of 6 months and control group not involved in IAYT.

Table 3 shows age and gender distribution of prediabetic population. In "Age group of 30–40 years out of 100 subjects" female was 65 and males 35. In age group between 41 and 50 years Out of 150 subject females were 100 and male 50, majority of subjects were females belongs to 41–50 years age group. Mean age in control group was 44.5 ± 3.8 years and in study group was 45.8 ± 4.1 years.

Table 4 depicts mean and standard deviations of LF, HF, LF/HF ratio and CIMT in control and study groups at baseline and after 6 months of intervention. The appropriate tool for the 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%.

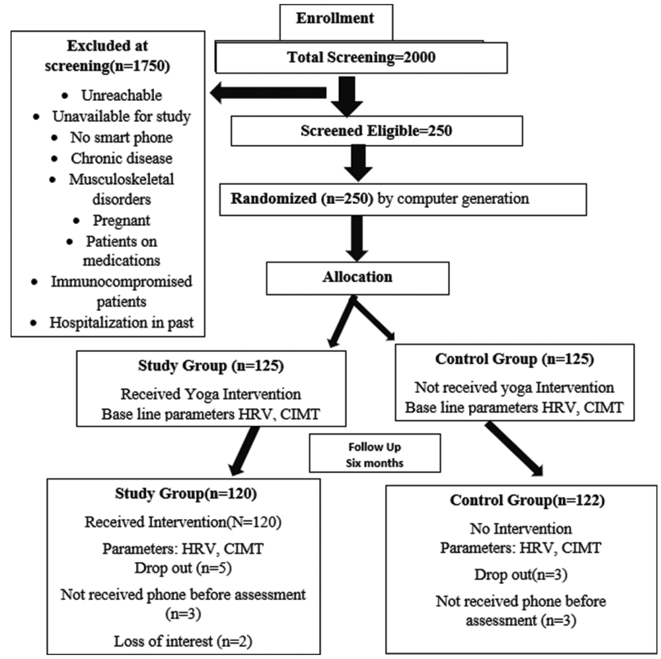

Figure 1: Flow chart showing patient recruitment and follow-up

Table 3: Age and gender distribution of prediabetic subjects

Age group (years)	Male	Female	Total
30-40	35	65	100
41-50	50	100	150
Total	85	165	250

Table 4: Intragroup comparison of results of heart rate variability and carotid intima media thickness

Parameters	Mean±SD		*P*
	Pre (baseline)	Post (after 6 months)	
LF			
Control	65.72±11.44	67.82±12.44	0.876
Study	66.67±11.87	40.67±13.9	<0.001
HF			
Control	45.90±11.79	36.85±12.08	0.689
Study	46.40±11.75	67.56±13.06	<0.001
LF/HF ratio			
Control	2.18±1.09	2.20±1.05	0.8862
Study	2.19±1.09	0.57±0.54	<0.0001
CIMT			
Control	0.70±0.07	0.70±0.05	0.22
Study	0.71±0.05	0.69±0.073	0.05

SD=Standard deviation, LF=Low-frequency, HF=High frequency, CIMT=Carotid-intima-media-thickness

In control group, pre- and post-results were not significant, whereas study group there was “significant reduction in, LF and (LF/HF Ratio), CIMT, and significant increase in HF” after 6 months of yoga intervention.

Table 5 depicts mean and standard deviations of LF, HF, LF/HF ratio and CIMT in control and study groups at baseline and after 6 months of intervention. ANCOVA was used to compare groups’ difference after adjustment of baseline differences at the significance level of 5%. Results showed that the covariate significantly predicts the dependent variable that were post-CIMT and post-LF/HF ratio, because the significance value is <0.05. Therefore, the post-CIMT and post-LF/HF ratio is influenced by their pre-CIMT and pre-LF/HF ratio. The CIMT values were almost same before intervention 0.70 ± 0.07 and at the postintervention 0.70 ± 0.05 in the control group and decreased from 0.71 ± 0.05 to 0.69 ± 0.073 in the study group. The results for CIMT in the study group showed a significant change than the control group. The amount of variation in CIMT accounted by the model has increased to 0.377 (corrected model) of which group accounts for 0.228. Most important, the large amount of variation in CIMT that is accounted for by the covariate has meant that the unexplained variance has been reduced to 0.609. Results showed that the LF/HF ratio values were increased from 2.18 ± 1.09 to 2.20 ± 1.05 at the postintervention in the control group and significantly decreased from 2.19 ± 1.09 to 0.57 ± 0.54 in the study group. The amount of variation in LF/HF ratio accounted by this model has increased to 119.162 (corrected model), of which group accounts for 116.914. Most important, the large amount of variation in LF/HF ratio that is accounted for by the covariate has meant that the unexplained variance has been reduced to 42.466. In this study, ANCOVA concluded that, in the study group, significant (P < 0.001 ANCOVA) decreased CIMT and LF/HF ratio after the IAYT compared to the control group.

Table 6 depicts Pearson correlation analysis between LF/HF ratio of HRV and CIMT in control and study groups results depict at base line in control and study group results of Pearson correlation were nonsignificant, and after 6 months of yoga intervention, Pearson correlation analysis in study group was positive and significant (strength strong).

Discussion

In this study, CIMT as a marker of subclinical atherosclerosis was associated with alterations of HRV indicating an impaired cardiac autonomic dysfunction in prediabetes. Our results are in line with the hypothesis that carotid atherosclerotic lesions are associated with impaired autonomic nervous system (ANS) function. Regular yoga represents a valuable strategy for control of risk factors of CHD (like hypertension, diabetes, obesity, lipids and stress), counter impairments of cardiac autonomic activity and artery structural changes, regression of atherosclerosis and secondary prevention of coronary heart disease.

Autonomic balance is body’s capability to maintain balance and stability in internal and external stimuli. Autonomic nervous system plays an important role in bringing about adaptation to environmental changes in human body.[4]

Table 5: Analysis of covariance in control and study group between variables (carotid-intima-media-thickness and low-frequency/high frequency ratio)

Source	Mean±SD		Sum of squares	df	Mean square	*F* test	Significance
	Pre	Post					
CIMT							
Control	0.70±0.07	0.70±0.05					
Study	0.71±0.05	0.69±0.073					
Corrected model			0.377	2	0.188	76.348	0.000
Intercept			0.203	1	0.203	82.313	0.000
Pre-CIMT			0.179	1	0.179	72.546	0.000
Group			0.228	1	0.228	92.593	0.000
Error			0.609	247	0.002		
Total			114.764	250			
Corrected total			0.986	249			
HRV LF/HF ratio							
Control	2.18±1.09	2.19±1.09					
Study	2.19±1.09	0.57±0.54					
Corrected model			119.162	2	59.581	346.546	0.000
Intercept			13.341	1	13.341	77.598	0.000
Pre-LF/HF ratio			14.522	1	14.522	84.468	0.000
Group			116.914	1	116.914	680.020	0.000
Error			42.466	247	0.172		
Total			532.753	250			

LF=Low-frequency, HF=High frequency, CIMT=Carotid-intima-media-thickness, HRV=Heart rate variability, SD=Standard deviation

Table 6: Pearson correlation significance in control and study group between carotid-intima-media-thickness and low-frequency/high frequency ratio

CIMT	HRV							
	Control pre-LF/HF ratio		Post-LF/HF ratio		Study pre-LF/HF ratio		Post-LF/HF ratio	
	Pearson correlation	Significance (two-tailed)	Pearson correlation	Significance (two-tailed)	Pearson correlation	Significance (two-tailed)	Pearson correlation	Significance (two-tailed)
Pre-CIMT (mm)	−0.079	0.381	−0.068	0.454	0.086	0.338	−0.076	0.398
Post-CIMT (mm)	0.097	0.280	0.001	0.988	−0.063	0.483	0.665	0.01

LF=Low-frequency, HF=High frequency, CIMT=Carotid-intima-media-thickness, HRV=Heart rate variability

Sympathetic nervous system over activity in the form of profound hyperglycemia in response to epinephrine was found to be an etiological factor in Type II diabetes.[5,6]

HRV has emerged as a simple, noninvasive way to assess sympathovagal balance at the sinoatrial level to assess autonomic status, health, and fitness.[23] HRV measured using intervals between two consecutive heart beats for normal sinus discharge.[24] HRV was a powerful tool for investigating the effect of ANS on the cardiovascular system. Autonomic dysfunction can adversely affect heart function. HRV can serve as a sensitive method of diagnosing early changes in cardiac autonomic functions.[25,26] In the present study, postintervention significant decrease in LF power spectrum (66.67 ± 11.87–40.69 ± 13.9: $P < 0.001$) when compared to control group (65.72 ± 11.87–67.82 ± 12.44: $P = 0.876$) LF/HF ratio were observed in the study group (2.19 ± 1.09–0.57 ± 0.54; $P < 0.001$) when compared to control group (2.18 ± 1.09–2.20 ± 1.05; $P = 0.886$) and significant increase in "HF power spectrum" in study group (46.40 ± 11.87–67.56 ± 13.06: $P < 0.001$) when compared to control group (45.90 ± 11.79–36.85 ± 12.08: $P = 0.689$). Postintervention shows "significant decrease" in CIMT was observed in the study group (71 ± 0.071–0.69 ± 0.073; $P < 0.01$) when compare to control group (0.70 ± 0.07–0.70 ± 0.05; $P = 0.22$) [Table 4].

Meshram and Meshram[18] reported in a yoga intervention study conducted over a period of 6 months observed that post yoga there was "significant decrease in LF" power spectrum (59.12 + 3.65–56.90 + 3.57) and LF/HF ratio (2.49 + 0.18–2.19 + 0.19) and significant increase in HF power (23.7 + 1.55–26.0 + 2.15), similar to the present study.

Vinay *et al*.[27] reported in a yoga intervention study conducted over a period of 1 month, which "included a set of postures, breathing practices, and meditation" for an hour daily for 1 month and observed that postyoga significant decrease in LF power spectrum (LF) (39.30–30.40) and LF/HF ratio (2.62–2.28), finding was similar to the present study.

Tulppo *et al*.[28] studied the effects of moderate and high-volume aerobic training on the time and frequency domain parameters of HRV indices over a period of 2 weeks. In moderate volume group, aerobic training was six session per week at an "intensity of 70%–80% of the maximum heart rate for duration of 30 min/session, and similar for 60 min/session in the high-volume" aerobic group, the results are compared to the present study, in which after 6 months of yoga intervention significantly increase in frequency domain parameter.

Hautala *et al*.[29] and Billman and Kukielka,[30] Kacker *et al*.[31] reported that after yoga intervention significant decreased ($P < 0.05$) in LF component and LF/HF ratio and significant increase ($P < 0.05$) in HF component which represent the shifting of autonomic nervous system in favor of parasympathetic component similar to the present study.

In the present study, positive significant correlation between HRV and CIMT was observed which was similar with a study done by Pereira *et al*.[32] which reported CIMT as a marker of subclinical atherosclerosis is associated with impaired cardiac autonomic control.

Galetta *et al*.[33] reported the effect of physical activity on HRV and CIMT in elderly subjects and the relationship between HRV and IMT. Elderly athletes had evidence of increased vagal activity in the frequency domain (HF and LF/HF ratio, $P < 0.01$) with respect to sedentary subjects. Moreover, athletes showed lower IMT compared to control subjects ($P < 0.01$). In the whole population, LF/HF ratio related positively to CIMT similar to the present study.

Čelovská *et al*.[34] reported an increased CIMT was associated with a significant decrease in baroreflex sensitivity in prehypertensive and hypertensives in the present study CIMT positively linked with LF/HF ratio. Meyer *et al*.[35] and Gottsater *et al*.[36] reported that, in type 2 diabetic patients, cardiovascular autonomic neuropathy was associated with carotid atherosclerosis. Gottsater *et al*.[37] and Miyamoto *et al*.[38] reported that decreased HRV as a measure of cardiac autonomic neuropathy may predict the progression of carotid atherosclerosis in Type 2 diabetes. Heponiemi *et al*.[39] and Chumaeva *et al*.[40] reported that, after lifestyle modification, improvement in cardiac autonomic reactivity was associated with lower CIMT even after adjusting for cardiovascular risk factors similar to the present study.

Saboo *et al*. reported that 6 months intensive lifestyle modification intervention in prediabetics improved glycemic control, lipid profile, and decreased progression of CIMT.[41]

Effect of yoga intervention on cardiac autonomic function can be assessed. These assessments would shed light on the short-term yogic practices. Therefore, it is appropriate to daily practice of yoga for sustain and enhance beneficial effects on cardiac autonomic functions.

Conclusion

This preliminary study indicates the importance of yoga intervention on the autonomic nervous system in prediabetes; in addition, yoga programs would be a risk reduction approach for Type 2 diabetes and its complications. Therefore, yoga programs could be an interventional approach to decrease cardiovascular risk and increasing exercise efficacy in prediabetic group that perform yoga. Yoga practices appear to improve autonomic regulation and enhance vagal dominance as presented by HRV. It confirms that the regular yoga represents a valuable strategy to counter impairments of cardiac autonomic activity and artery structural changes. Therefore, it is appropriate to daily practice of yoga for sustain and enhance beneficial effects on cardiac autonomic functions and CIMT.

Ethical clearance

Ethical clearance was obtained (EC/P/01/2016) by the institutional ethical committee of Rajasthan University of Health Sciences.

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Conflicts of interest

There are no conflicts of interest.

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