Original Article

A Study to Assess and Correlate Metabolic Parameters with Carotid Intima-Media Thickness after Combined Approach of Yoga Therapy among Prediabetics

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Abstract

Background: Prediabetes is an intermediate hyperglycemia in which the fasting blood glucose (FBG) level is greater than normal (100–125 mg/dl) but lower than diabetic levels (more than 125 mg/dl). The aim of the present study was to evaluate and correlate the impact of the combined approach of yoga therapy (CAYT) on carotid intima-media thickness (CIMT) and metabolic parameters including FBG, glycated hemoglobin (HbA1C), and lipid profile-like triglyceride (TG), total cholesterol (TC), and high-density lipoprotein (HDL).

Materials and Methods: Experimental Interventional study was conducted on a total of 250 prediabetics divided into the control (n = 125) and study group (n = 125) at "RUHS College of Medical Sciences and associated hospitals." Assessments were made at baseline and after six months of the CAYT. The study group (n = 125) was engaged in the CAYT, which consists of yoga, dietary modification, counseling, and follow-up. The control group not participated in CAYT.

Result: Mean age of participants was 45.3 ± 5.4 years**.** Pearson correlation analysis of CIMT and metabolic parameters which were fasting blood sugar, HbA1C, and lipid parameters (TC, TG, and HDL) showed that significant positive correlation with FBG (r = .880), HbA1C (r = .514), TC (r = .523), TG (r = .832), and negative correlation with HDL (r = -0.591) after six months of CAYT.

Conclusion: This study demonstrated that after six months of CAYT metabolic parameters, CIMT were significantly decreased. We have observed a significant correlation exists between CIMT and metabolic parameters. Therefore, regular CIMT measurement might be beneficial for the assessment of cardiovascular disease (CVD) risk and facilitate better use of treatment modalities in prediabetics.

Keywords: Cardiovascular disease, carotid intima-media thickness, prediabetes, risk factors, type 2 diabetes, yoga

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Introduction

Prediabetes is defined as an intermediate stage between normal glucose tolerance and type 2 diabetes mellitus (T2DM). According to the American diabetes association, prediabetes diagnostic criteria were raised fasting plasma glucose level (100 mg/dL–125 mg/dL), glycated hemoglobin (HbA1c) 5.7%-6.4%, and results of oral glucose tolerance test showed an increased level of blood glucose (140–199 mg/dL) after oral administration of 75-gram glucose solution.[1]

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The prevalence of prediabetes and diabetes in India was 24.5% and 9.3%, respectively.[2] Almost 60% of prediabetics with impaired fasting glucose turn into people with diabetes in one-year follow-up.[3] The risk factors such as altered glucose level in the blood, central obesity, swelling, alteration in endothelial function, and oxidative stress during prediabetes are primarily involved in the progression of cardiovascular ailment.[4] Age, male sex, family history of diabetes,

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hypertension, and obesity were risk factors for diabetes in urban and rural areas.[5]

In prediabetes, insulin resistance and β-cell dysfunction occur, leading to a decrease in insulin secretion which impaired homeostasis of glucose levels. However, when both insulin resistance and β-cell dysfunction were present, hyperglycemia is amplified leading to the advancement of prediabetes to T2DM.[6] Previous studies reported that prediabetes is linked with a proatherogenic profile presented with increased triacylglycerol, total cholesterol (TL), low-density lipoprotein (LDL), and decreased levels of high-density lipoprotein (HDL), which may lead to the progression of atherosclerosis and increase the progression of cardiovascular disease (CVD).[6,7] Endothelial dysfunction associated with diabetes and CVD is characterized by changes in vaso regulation, increased generation of reactive oxygen intermediates, polyol pathway activation, inflammatory activation, mitochondrial dysfunction, increased production of advanced glycation end-products, activation of protein kinase C (PKC), which leads to dysfunction of endothelium by apoptosis and senescence, microRNAs dysregulation.[8]

Carotid intima-media thickness (CIMT) is a diagnostic marker for CVD, it is a risk factor, and a modality for the diagnosis of atherosclerosis and can be useful for the assessment of risk stratification.[9]

Sheng[10] *et al*. reported that lifestyle modifications, which include dietary modification, physical activity and weight loss promising long-term strategies involving contribute to health by decreasing weight, body mass index (BMI), waist–hip ratio, systolic and diastolic blood pressure (DBP), fasting blood glucose (FBG), triglyceride (TG), TL, and by raising HDL levels. In people with prediabetes, who exhibit impaired glucose tolerance as a result of peripheral insulin resistance, lifestyle modification can improve insulin sensitivity and restore normoglycemia.[11]

In India, yoga originated over 5000 years ago for developing mental faculties.[12] According to yoga a healthy mind leads to a healthy body.[13] The yoga methods include the various postures and practices of pranayama, which regulates breathing through different asana, which consists of a variety of poses in a coordinated manner combined with controlled breathing practices.[14] These yoga postures and pranayama positively impact neuroendocrinal, biochemical, and neurotransmitters, hormonal changes that reduce stress levels and increase psychological well-being. In various poses, forward bending and massage pressurize on the pancreas increased the recession of GLUT-4 receptors to stimulate insulin secretion.[15] In the previous study reported that lifestyle modifications such as an increase in physical activity like yoga can be an effective low-cost nonpharmacologic therapy to stop the progression of prediabetes to T2DM.[16,17]

However, very few studies were available to observe and correlate the efficacy of yoga on CIMT and metabolic parameters among prediabetics. Therefore, this study was designed to observe and correlate the effect of the combined approach of yoga therapy (CAYT) on CIMT and metabolic parameters which were blood glucose (FBG), HbA1c, lipid profile; TC, TG, HDL. The novelty of this study was the correlation analysis of metabolic parameters with CIMT.

Materials and Methods

This experimental interventional study was carried out after the screening of a total of 2000 participants out of 250 people with prediabetes who were recruited at the "RUHS College of Medical Sciences and Associated hospitals." Assessments were conducted at the beginning and after six months of CAYT. People with prediabetes were divided into the study group (n = 125) which underwent CAYT, and the control group (n = 125), not involved in CAYT.

The sample size was calculated by the prevalence of prediabetes taken as 9.3% as a reference article by Mathur *et al*.[2] Using the proper statistical formula, n = z2pq/d2, the sample size is calculated. Prevalence was. 09 denoted by P, Z statistic is the corresponds to the confidence level, and q was complement of p calculated as (1-p) equal to. 91. The targeted sample size in each group with a 95% confidence interval was 125 to reach the sample size with a 5% allowable error (precision) and 10% non-response rate.

According to American Diabetic Association criteria, participants who have FBG levels between 110 to 125 mg/dl, HbA1c in the range of 5.7–6.4%, participants who have systolic blood pressure (SBP) less than 160, and DBP less than 100 mm hg, with no personal and family history of CVD were included. Subjects who have alanine aminotransferase greater than 55 U/L, aspartate aminotransferase greater than 48 U/L, renal dysfunction, retinopathy, neuropathy, nephropathy, alcoholics, and any disease that required hospitalization were excluded.

Ethical approval (ECR/P/762/Inst/EC/01/2016) was obtained by the institutional ethical committee, study participants explained the objectives and significance of the study, and participants who satisfied inclusion criteria were recruited. Written informed consent forms were obtained from all participants. Assessment of anthropometric parameters such as BMI and waist–hip ratio were performed. A digital physiograph was used to measure clinical parameters such as pulse, SBP, DBP, and an electrocardiogram was measured for the study and control groups. At baseline and six months later, biochemical markers like FBG, HbA1C, and serum lipid profile were evaluated.

An eight MHz linear probe was used to modify the B mode Acuson Sequoia ultrasonography device to measure the CIMT on the posterior wall of the carotid arteries. The average measurement duration for CIMT was 30 minutes. Radiologists performed all scans. Cardiometabolic parameters were evaluated at baseline and after six months of CAYT [Table 1].

Table 1: Yoga protocol

Yogic practices	Duration
Prayer	3 Min
Omkar recitation	3 Min
Pranayama	5 Min
Various Postures (asanas) (Surya Namaskar, Bhujangasana, Padmasana, Pashimottanasana, Sukhasana, Trikonasana, Tadasana, Sarvangasana, Pawanmuktasana, Ardhmatsyendrasana)	30 Min
Shavasana	5 Min

Four elements make up theCAYT: yoga, food modification in diet, counseling, and follow-up. Yoga protocols include prayer, omkar, breathing exercises (pranayama), and various asanas (such as Surya Namaskar, Bhujangasana, Padmasana, Pashimottanasana, Sukhasana, Trikonasana, Tadasana, Sarvangasana, Pawanmuktasana, Ardhmatsyendrasana), Shavasana [Table 1].

The certified yoga instructor explained and demonstrated yoga asanas and posture at yoga labs. Each yoga session lasted forty-six minutes six days a week over six months. The subjects were motivated to perform all the yoga postures as precisely as they could. Study participants were relaxed with Shavasana at the end of each session.

All the subjects received the same diet plan from a certified dietician as per Asian Indian dietary guidelines.[18] The diet modification plan included 50%–60% complex carbohydrates, total fat intake, and saturated fat intake should be less than 30% and, 10% of calories, respectively. Dietary fat should be polyunsaturated or monounsaturated up to 10% of calories, 10–15% protein, 25–40 g dietary fiber, and salt intake should be <5 g. All people with prediabetes in the study group should be motivated to decrease their consumption of chicken, eggs, red meat, fish, refined grains, and white sugars. Participants were followed up with about diet and yoga through weekly online sessions on Google Meet. The subjects were told to keep a record of their daily diet and yoga practices. Daily messaging, weekly phone calls with the subjects and their families, and monthly diary checks were used to monitor compliance.

Statistical analysis

Intragroup comparisons were made between the study group by paired ttest and intergroup comparisons between the study and control group by unpaired *t*-test. Pearson correlation analysis was computed among control and study groups to analyze the correlation of carotid intima-media thickness with biochemical parameters which were FBG, HbA1C, lipid profile; TC, TG, and HDL.

Results

The mean age of the participants was 45.3 ± 5.4 years. All the parameters were quantitative. The aim of this study was to observe and correlate the effect of CAYT on carotid intima-media thickness and metabolic parameters. Various parameters of the data were evaluated at baseline and after CAYT.

In this study, the total subjects screened were 2000 out of 250 prediabetics recruited and the prevalence rate was 12.5%. In the 30–40 years age group, out of 100 subjects, males were 35 and females 65 in number. Of the 41–50 years age group, out of 150 subjects, 50 were males, and 100 were females, the majority of subjects were females in the age group of 41–50 years age group.

Table 2 depicts baseline parameters, i.e., BMI, "waist-hip ratio," SBP, and DBP in both groups at baseline and after six months of CAYT. Results were significant in the study group. In the control group, result were insignificant.

Table 3 depicts a correlation analysis of CIMT with baseline parameters which were BMI, waist–hip ratio, SBP, and DBP in the control and study groups. After six months of CAYT in the study group BMI, waist–hip ratio, and SBP and DBP showed positive and significant correlation with carotid intima-media thickness.

Table 4 depicts the correlation analysis showed that in the study group significant positive correlation of CIMT with FBG (r = 0.881), HbA1C (r = 0.514), TG (r = 0.832), TC (r = 0.523), and negative correlation with HDL (r = -.591) after six months of CAYT that indicating that yoga intervention significantly decreased blood glucose level, HbA1c, and lipid profile.

Discussion

Carotid intima-media thickness is a diagnostic tool to predict subclinical atherosclerosis, which is an early predictor of endothelial dysfunction and cardiovascular disorders.[9] Aim of the present study was to observe and correlate the effect of six months of combined approach of yoga therapy on CIMT and metabolic parameters which were FBG, HbA1C, lipid profile; cholesterol, TG, and HDL.

In this study Table 2 depicts after six months of combined approach of yoga therapy BMI, WHR, SBP, DBP and Pulse rate were significantly decreased in study group compare to control group similar to previous studies.[15,16]

The result of the present study showed in Tables 3 and 4 a significant positive correlation between BMI, waist–hip ratio, SBP, DBP, and metabolic parameters like blood glucose, HbA1c, TG, and cholesterol with the carotid intima-media thickness, negative correlation with HDL similar to the study done by Kanakaraju *et al*.,[19] found a significant correlation had occurred with the parameters like BMI, waist-hip ratio, blood glucose, HbA1C, and lipid parameters: LDL, TL, and TG.

The probable mechanism of increasing the atherosclerotic process in the prediabetic stage is due to alterations in vascular tissue. Receptor interaction with glycosylated proteins leads to the initiation of proinflammatory responses and oxidative stress, alteration of growth factor expression with PKC

Table 2: Baseline parameters in control and study group

Parameters	Control group (Baseline)	Control group (After 6 months)	*P*	Study group (Baseline)	Study group (After 6 months)	*P*
BMI	28.6±3	28.7±4	NS	27.8±7	26.8±3	<0.01*
Waist-hip Ratio	0.90±6	0.92±7	NS	0.91±7	0.85±4	<0.001*
Blood pressure SBP	152±8.3	151±7.4	NS	154±8.4	130.7±10.1	<0.002*
DBP	90.8±4.2	90.5±4.3	NS	92.8±4.2	86.3±3.9	<0.001*
Pulse Rate	90.2±9.8	90.1±8.8	NS	89.2±9.7	82±8. 6	<0.001*

BMI=Body mass index, SBP=Systolic blood pressure, DBP=Diastolic blood pressure. *P*<0.05; significant*

Table 3: Pearson correlation significance in control and study group between carotid intima-media thickness, body mass index, waist-hip ratio, systolic and diastolic blood pressure (DBP) in control and study group

Parameters	Control/CIMT (mm) (Baseline)		Post/CIMT (mm) (After 6 months)		Study/CIMT (mm) (Baseline)		Study/CIMT (mm) (After 6 months)	
	Pearson correlation	Significance (two-tailed)	Pearson correlation	Significance (two-tailed)	Pearson correlation	Significance (two-tailed)	Pearson correlation	Significance (two-tailed)
BMI (Kg/m^2) (Baseline)	0.043	0.631	-.131	0.145	0.073	0.444	0.245	0.531
BMI (Kg/m^2) (After 6 months)	0.138	0.125	-.061	0.496	0.438	0.235	0.386	0.051*
Waist-hip ratio (Baseline)	-.068	0.453	0.038	0.675	-.073	0.393	0.475	0.048*
Waist-hip ratio (After 6 months)	0.043	0.632	0.014	0.881	0.033	0.551	0.732	0.024*
SBP (mmHg) (Baseline)	-.088	0.328	-.158	0.079	-.054	0.528	0.479	0.053*
SBP (mmHg) (After 6 months)	-.053	0.557	0.059	0.512	-.023	0.432	0.312	0.048*
DBP (mmHg) (Baseline)	-.096	0.288	0.003	0.977	-.056	0.188	0.777	0.026*
DBP (mmHg) (After 6 months)	-.085	0.344	-.022	0.805	-.055	0.456	0.605	0.012*

BMI=Body mass index, SBP=Systolic blood pressure, DBP=Diastolic blood pressure. *P*<0.05; significant*

Table 4: Pearson correlation analysis in the study group between carotid intima-media thickness and metabolic parameters at baseline and after 6 months of the combined approach of yoga therapy

Parameters	Mean±SD	CIMT (mm) (Baseline)		CIMT (mm) (After 6 months)	
		Pearson correlation	Significance (two-tailed)	Pearson correlation	Significance (two-tailed)
Study group		0.71±0.05		0.69±0.073	
FBG (mg/dl) (Baseline)	116.87±4.57	0.068	0.453	0.238	0.675
FBG (mg/dl) (After 6 months)	108.17±5.373	0.043	0.632	0.881	0.05*
HbA1C% (Baseline)	6.42±0.86	0.055	0.030	0.317	0.015*
HbA1C% (After 6 months)	5.67±0.40	0.030	0.743	0.514	0.01*
TG (mg/dl) (Baseline)	133.36±7.52	0.051	0.57	0.01	0.88
TG (mg/dl) (After 6 months)	126.78±8.10	-0.005	0.955	0.832	0.019 *
TC ((mg/dl) Baseline)	186.92±26.42	0.042	0.642	0.026	0.772
TC (mg/dl) (After 6 months)	179.78±24.98	-.071	0.018	0.523	0.048 *
HDL (mg/dl) (Baseline)	44.88±3.22	0.043	0.636	0.109	0.225
HDL (mg/dl) (After 6 months)	45.28±2.35	0.037	0.682	-.591	0.05 *

FBG=Fasting blood glucose, HbA1C=Glycated hemoglobin, TC=Total cholesterol, TG=Triglyceride, HDL=High-density lipoprotein. *P*<05; significant*

activation, intracellular glucose shunted in hexosamine pathway leads to glycosylation of enzymes which disturb normal enzymatic function.[13-16]

Regular yoga practices represent a valuable, cost-effective tool for the control of risk factors of coronary heart disease (stress, hypertension, obesity, diabetes, dyslipidemia), counter impairments of artery structural changes, and cardiac autonomic activity that leads to primary prevention of coronary heart disease by the decreased progression of atherosclerosis.[20]

The result of the present study in Table 4 depicts that FBG and CIMT have a significant positive correlation similar to the studies by Kanakaraju *et al*.,[19] and Gao *et al*.[21]

This study in Table 4 depicts that HbA1c and CIMT have a positive and significant correlation, indicating increased HbA1c linked with the progression of CIMT. Similar to studies done by Nazish S[22] have shown similar findings that indicate HbA1c is also a predictor of initial stages of carotid artery atherosclerosis and cardiovascular mortality. Al-Khaqan[23] *et al*. and Lee[24] *et al.* reported correlation analysis of HbA1c

data belonging showed a significant correlation with CIMT, results were in concurrence with the present study.

In this current study, Table 4 results showed a significant correlation between CIMT with various lipid parameters like TG, cholesterol, and HDLs. Still, the strength of correlation was positive for TG and cholesterol and a negative correlation with HDL indicating that the, increased levels of TG, and TC, were associated with a higher risk of late-stage atherosclerosis results were similar to Ashfaque *et al.*,[25] Okafor *et al.*[26] reported a positive correlation between CIMT and TC, TG. The results of this study suggested it is essential to maintain dyslipidemia at normal levels to reduce the burden of CVD. The increase in hepatic lipase and lipoprotein lipase at the cellular level, which influences the metabolism of lipoprotein and consequently enhances the uptake of TGs by fatty tissues, maybe the mechanism of action of the improvement in the lipid profile after yoga.[27]

Kaur[28] *et al.* reported that the yoga intervention improves the cardiometabolic parameters of people with prediabetes in reference to their glucose tolerance and lipid profile similar to the present study. However, the changes observed after six months of CAYT occur via at least two major pathways. First, by decreasing stimulation of the hypothalamic-pituitary-adrenal axis and the sympathoadrenal system. yoga may alleviate the effects of stress, promoting feelings of well-being and fostering positive downstream impacts on metabolic function, systemic inflammatory responses, and the neuroendocrine system.[28-30] Second, yoga directly stimulated vagus nerve that causes increase activation of the parasympathetic system that lead to changes in cardiovagal function.[31-32]

Conclusion

Prediabetes is a condition that occurs before diabetes develops, in which blood glucose levels were higher but do not reach the diagnostic levels of T2DM. This study demonstrated that, after CAYT, cardiometabolic parameters were significantly decreased, and metabolic parameters were positively correlated with CIMT. It demonstrates that practicing yoga regularly is an effective way to prevent changes in arterial structure and impairments of cardiometabolic parameters. Therefore, regular assessment of CIMT adds value to the risk stratification and use of different treatment modalities for prediabetics.

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Conflict of interest

There are no conflicts of interest.

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