Effect of 3-Month Yoga on Oxidative Stress in Type 2 Diabetes With or Without Complications

A controlled clinical trial

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OBJECTIVE—To assess the effect of yoga on anthropometry, blood pressure, glycemic control, and oxidative stress in type 2 diabetic patients on standard care in comparison with standard care alone.

RESEARCH DESIGN AND METHODS—The study involved 123 patients stratified according to groups with microvascular complications, macrovascular complications, and peripheral neuropathy and without complications and assigned to receive either standard care or standard care along with additional yoga for 3 months.

RESULTS—In comparison with standard care alone, yoga resulted in significant reduction in BMI, glycemic control, and malondialdehyde and increase in glutathione and vitamin C. There were no differences in waist circumference, waist-to-hip ratio, blood pressure, vitamin E, or superoxide dismutase in the yoga group at follow-up.

CONCLUSIONS—Yoga can be used as an effective therapy in reducing oxidative stress in type 2 diabetes. Yoga in addition to standard care helps reduce BMI and improve glycemic control in type 2 diabetic patients.

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Oxidative stress has been implicated as the root cause underlying the development of insulin resistance, β-cell dysfunction, diabetes, and its associated clinical conditions such as atherosclerosis, microvascular complications, and neuropathy (1,2). Yoga has been found to be beneficial in reducing oxidative stress in type 2 diabetes (3,4), but there is a lack of controlled trials to demonstrate the same. This report describes the effect of yoga on oxidative stress, glycemic control, blood pressure control, and anthropometry in type 2 diabetic patients with or without complications compared with control subjects on standard care.

RESEARCH DESIGN AND METHODS

This study was conducted at the diabetes clinic of Kasturba Medical College hospital and at four community diabetes clinics offering primary care to diabetic patients in Mangalore, India. A total of 123 type 2 diabetic patients aged between 40 and 75 years, none of whom were alcoholics or smokers, gave written informed consent and were included. Patients with acute macrovascular complications, cancer, pulmonary tuberculosis, and rheumatoid arthritis and those who were unable to perform yoga were excluded. Patients were grouped as 60 for yoga and 63 for control. Stratified sampling was used at the time of allocation to maintain an equal number of patients with uncomplicated diabetes and with microvascular, macrovascular, and peripheral neuropathy in these groups.

Three months' yoga included tadasana, padahastasana, vrikshasana, trikonasana, parshvothanasana, vajrasana, vakrasana, gomukasana, paschimotasana, uttanapadasana, pawanamuktasana, bhujangasana, shalabasana, dhanurasana, viparitakarani, sitkari and bhramari pranayama, anuloma viloma, and shavasana poses. The control group at their baseline visit was given general oral and written information about diet and exercise. Compliance with the intervention was defined as attendance for at least 3 days/week at the yoga center for 3 months. Drug dosages with regard to diabetes and blood pressure were kept constant throughout the study period.

Malondialdehyde (5), glutathione (6), superoxide dismutase (7), vitamin C (8), and vitamin E (9) were measured to assess the oxidative stress and antioxidant status. BMI, waist circumference, waist-to-hip ratio, blood pressure, fasting plasma glucose (FPG), postprandial plasma glucose (PPPG), and HbA_{1c} were analyzed.

Data were analyzed using SPSS version 11.0. Paired *t* test was used to compare the continuous variables from baseline to follow-up. Mann-Whitney *U* test, a nonparametric test, was used to compare the differences in various parameters before and after intervention between the two groups.

RESULTS

Three participants withdrew from yoga intervention during the first month of the study and were not included in the final analysis. Among these, two moved their residence and one reported illness unrelated to the study. Mean ± SD age was 59.8 ± 9.9 years for the yoga group and 57.5 ± 8.9 years in the control group. There were no significant differences in sex, duration of diabetes, or hypertension between the groups at baseline. Average attendance at the yoga classes was 82–88%.

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Table 1—*Parameters at baseline and after 3 months*

	Yoga group (n = 60)			Control group (n = 63)			
	Baseline	After 3 months	Change at 3 months	Baseline	After 3 months	Change at 3 months	*P*
FPG (mmol/L)	8.1 ± 2.6	7.3 ± 2.3	−0.8 ± 0.3	8.6 ± 3.1	9.0 ± 3.0	0.4 ± 0.1	<0.001
PPPG (mmol/L)	12.0 ± 4.0	10.9 ± 3.6	−1.1 ± 0.4	12.3 ± 5.1	12.6 ± 4.7	0.3 ± 0.4	<0.03
HbA_{1c} (%)	8.4 ± 1.3	8.3 ± 1.5	−0.1 ± 0.2	8.0 ± 1.5	8.5 ± 1.8	0.5 ± 0.3	<0.001
BMI (kg/m^2)	25.9 ± 3.5	25.4 ± 3.4	−0.5 ± 0.1	25.3 ± 3.9	25.5 ± 4.1	0.3 ± 0.2	<0.001
Waist circumference (cm)	92.9 ± 9.5	92.7 ± 9.4	−0.2 ± 0.1	90.5 ± 9.8	90.0 ± 9.1	−0.5 ± 0.7	0.903
Waist-to-hip ratio	0.93 ± 0.08	0.91 ± 0.07	−0.02 ± 0.01	0.93 ± 0.06	0.93 ± 0.05	0.0 ± 0.01	0.080
Systolic blood pressure (mmHg)	137.8 ± 17.9	133.3 ± 13.8	−4.5 ± 4.1	139.6 ± 21.0	138.0 ± 15.4	−1.6 ± 5.6	0.166
Diastolic blood pressure (mmHg)	82.8 ± 9.3	79.8 ± 7.4	−3.0 ± 1.9	84.1 ± 9.9	83.9 ± 8.5	−0.2 ± 1.4	0.072
Malondialdehyde (μmol/L)	53.0 ± 11.3	42.2 ± 9.9	−10.8 ± 1.4	50.7 ± 9.3	52.3 ± 10.9	1.6 ± 1.6	<0.001
Glutathione (μmol/gmHb)	7.5 ± 2.6	8.3 ± 2.5	0.8 ± 0.1	7.1 ± 3.6	6.3 ± 2.4	−0.8 ± 1.2	<0.001
Vitamin C (μmol/L)	29.0 ± 27.8	37.0 ± 21.0	8.0 ± 6.8	30.0 ± 29.0	23.8 ± 18.2	−6.2 ± 10.8	<0.002
Vitamin E (μmol/L)	58.0 ± 18.6	59.7 ± 23.9	1.7 ± 5.3	59.7 ± 24.2	58.0 ± 23.5	−1.7 ± 0.7	0.238
Superoxide dismutase (units/gmHb)	5,669.9 ± 1,410.7	5,249.0 ± 1,247.2	−420.9 ± 163.5	5,691.6 ± 1,641.4	5,593.1 ± 1,768.0	−98.5 ± 126.6	0.121

Data are means ± SD. *P* values are significance values in yoga group compared with the control group.

Yoga practitioners achieved significant improvements in BMI, FPG, PPPG, HbA_{1c}, malondialdehyde, glutathione, and vitamin C at 3 months compared with the standard care group (Table 1). In the yoga group, the mean percentage reduction in malondialdehyde was 20% (−10.8 ± 1.4 μmol/L) and in HbA_{1c} 1.4% (−0.1 ± 0.2%). In the control group, the mean percentage increase in malondialdehyde was 3.2% (1.6 ± 1.6 μmol/L) and in HbA_{1c} 6.25% (0.5 ± 0.3%). Significant reductions in glutathione and vitamin C were seen in control subjects. No significant changes in waist circumference, waist-to-hip ratio, blood pressure, vitamin E, or superoxide dismutase were observed in the yoga group compared with control subjects. No adverse events were observed during the intervention period.

CONCLUSIONS—Yoga practitioners achieved a 20% reduction in oxidative stress, which is similar to the findings of Gordon et al. (10): 6 months of yoga in type 2 diabetic subjects showed a 19.9% reduction in oxidative stress. Other lifestyle interventions such as aerobic exercise and resistance training are known to increase stress parameters (11,12). Antioxidants like glutathione and vitamin C improved by 15 and nearly 60% compared with standard care. To the best of our knowledge, to date there are no reports of the effect of yoga on glutathione and vitamin status in type 2 diabetes. In this study, yoga improved the antioxidant levels, thereby reducing the oxidative stress in type 2 diabetic patients.

The effect on glycemic control and BMI was marginal compared with results obtained by other lifestyle interventions such as aerobic exercise and resistance training. In the current study, mean percentage reduction in HbA_{1c} was 1.4% in the yoga group, whereas it increased by 6.25% in the control group. From a clinical perspective, this represents a small change. However, long-term, regular practice of yoga can sustain the improved glycemic control brought about by standard care. Greatest improvements in HbA_{1c} values after yoga in type 2 diabetes have come from studies in which the sample sizes are small, about 10–30 in each group (4,13) and from studies where yoga was delivered along with exercises (14).

Skora-Kondza et al. (15) observed difficulty with adherence of patients to yoga intervention. This was overcome in our study because yoga classes were held

at several community centers in the city, which made it easy for the patients to attend the classes; in addition, culturally, Indian patients would accept yoga better than the Western population.

Our study is limited by the fact that the allocation to the groups was not randomized. Random allocation in community settings is difficult. In this study, social and environmental factors during these training sessions may have a beneficial influence on oxidative stress. The strength of our study was the stratification of sample according to complications. Participants with various complications may have increased oxidative stress; stratification made the two groups identical.

In conclusion, yoga can be used as an effective therapy in reducing oxidative stress in type 2 diabetes. Yoga is also beneficial in improving glycemic parameters and BMI and can be administered as an add-on therapy to standard lifestyle interventions. Yoga was not beneficial in reducing the blood pressure or waist circumference in this short-term study. Further studies are needed to confirm that yoga is beneficial in preventing the progression of diabetes and its complications.

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S.V.H. designed the study, acquired and interpreted data, and wrote the manuscript. P.A. developed the protocol, designed the study, interpreted data, and reviewed and edited the manuscript. S.K. analyzed data. V.J.P. acquired data and contributed to discussion. S.D. and V.D. reviewed and edited the manuscript.

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