Original Article

Effect of Yoga and Exercise on Glycemic Control and Psychosocial Parameters in Type 2 Diabetes Mellitus: A Randomized Controlled Study

Abstract

Context (Background): Type 2 diabetes has been strongly associated with psychosocial factors such as stress, anxiety, depression, and quality of life (QOL). There is not much evidence whether yoga can improve these factors and motivate individuals to engage in active lifestyle. **Aims:** This study aims to evaluate the effect of yoga and exercise over glycemic control, anxiety, depression, exercise self-efficacy (ESE), and QOL after 3-month program. **Methods:** Two hundred and twenty-seven individuals were randomly allocated to yoga group (YG) and exercise group. YG practiced yoga for 2 weeks under supervision and then carried out practice at home for 3 months. The exercise group practiced 30 min of brisk walking for 5 days a week. **Results:** On comparison among the groups, in YG, there was a mean change of 0.47 in glycated hemoglobin which was greater than mean reduction of 0.28 in the exercise group with $P < 0.05$. State anxiety reduced by 7.8 and trait anxiety reduced by 4.4 in YG ($P < 0.05$) in 3 months as compared to nonsignificant reductions of 3 and 1 in mean of state and trait anxiety scores in the exercise group ($P > 0.05$). There was a statistically significant reduction in depression score in both the groups, 8.6 in yoga and 4.0 in exercise, which was greater in YG. ESE improved by 19.2 in YG ($P < 0.05$), whereas it improved only 2.2 in the exercise group ($P > 0.05$). QOL improved by 23.7 in YG and 3.0 in the exercise group which was nonsignificant in the exercise group as compared to YG. **Conclusions:** Yoga is superior to exercise alone as a lifestyle modification program in improving glycemic control, anxiety, depression, and QOL as well as ESE.

Keywords: *Anxiety, depression, exercise, exercise self-efficacy, quality of life, yoga*

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Introduction

Type 2 diabetes is the most common form of diabetes which is directly associated to increasing stress due to changing lifestyle and dietary habits such as tobacco, alcohol, and low vegetable.[1] Patterns of type 2 diabetes are different in developed nations and developing nations such as India. The age range of 45–64 years comprises maximum patients with diabetes in Indian population as compared to ≥65 years in the USA. It implies that productive population of India is falling prey to type 2 diabetes, and this trend is increasing in urban India. The prevalence of type 2 diabetes has been found lower in low economic group as compared to high-income group (12.6% vs. 24.6% in ≥40 years of age), and this is directly related to physical activity where job nature of lower socioeconomic class involves moderate to strenuous physical activity at workplace. Abdominal adiposity is strongly and positively correlated with diabetes in India.[2]

Lifestyle modifications such as diet restrictions and increased physical activity are the mainstay of type 2 diabetes management along with medications. The findings of past studies were remarkable for their consistent findings in the protective effects of physical activity on the occurrence of type 2 diabetes.[3] In addition, some of the studies also showed a dose–response relationship between the frequency of physical activity and the degree of protective effect. These studies suggested a causative role for physical inactivity in type 2 diabetes.[3,4]

Stress and related entities such as anxiety and depression have been associated with pathophysiology of type 2 diabetes. Type 2 diabetes is directly related to modern life style which promotes sedentary life style and lesser physical activity. High stress level can overload the blood with high sugar

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as a response to stress. The pathophysiology of diabetes is bidirectional, and it cannot be clearly said whether diabetes causes stress or stress causes diabetes. However, from a clinician point of view, it is important to control the disease and its aftermath both. In such a situation, yoga seems to be promising.[5,6]

Yoga philosophy attributes most diseases to insufficient life force, either in the body as a whole, or a blockage of life force localized to one part of the body leading to decrease in immunity and increased susceptibility to infections.[7] Yoga emphasizes the treatment of the root cause and not only the symptoms. Patients with diabetes may benefit from yoga's ability to improve their glycemic control, stress, and overall quality of life (QOL).[7-9]

There is a clear need to study the efficacy of alternative therapies such as yoga because of its holistic nature, cost-effectiveness, and free of side effects.[9,10] The American Diabetes Association (ADA) position statement recommends that the use of adjuvant therapies be based on evidence from clinical research.[11]

There are certain inherent problems in the prevention and management of type 2 diabetes. Subjects of type 2 diabetes show greater compliance to medications and lower compliance to exercise and lifestyle modifications. Further, increasing intensity of exercise leads to more dropouts from an exercise program. Previous studies have shown some promise as how yoga may have more effective than exercise alone. Yoga acts through downregulating the hypothalamic–pituitary–adrenal (HPA) axis which gets hyperactivated as a response to abnormal physical or psychological demand (stressor). Yoga attenuates this stress cascade by reducing the perception of stress. Yoga decreases physiologic manifestations by reducing heart rate, blood pressure, and respiratory rate.[12,13] Reduction of cardiovascular risk factors in diabetes is a hallmark of successful diabetes management.[14-16] Mechanism of action of yoga can be hypothesized under two pathways: first, action of yoga by vagal stimulation, and second, by parasympathetic activation and HPA axis modification.[6] The first mechanism explains yoga's action through vagal stimulation by improving baroreflex sensitivity, reducing inflammatory cytokines, and thereby reducing blood pressure and resting heart rate.[16-19] It improves endothelial function and reduces risks for cardiovascular diseases in type 2 diabetes.[6]

The second postulated mechanism of action of yoga is through parasympathetic activation and associated antistress mechanisms. It reduces perceived stress and HPA axis activation, thereby improving overall metabolic and psychologic profiles.[6]

This study aims to evaluate whether yoga practices help to improve exercise self-efficacy (ESE). This study also tends to find the effect of yoga and exercise over stress and other psychosocial parameters such as anxiety, depression, and QOL. These factors are strongly associated with occurrence and postdisease state.

There is a paucity of literature evidence from randomized blinded trials with adequate sample. However, our literature search could not retrieve any study from northeast states of Indian population about these interventions in type 2 diabetes. This study aims to evaluate the effect of yoga and exercise over glycemic control, anxiety, depression, ESE, and QOL of life after 3-month program.

Methods

This randomized controlled trial of parallel design comprising two groups was conducted involving patients with type 2 diabetes from August 2011 to January 2014. Based on the prevalence of type 2 diabetes in Sikkim and effect size of 0.4 from a pilot study for primary outcome glycated hemoglobin (HbA1c), power at 80%, level of significance at 0.05, and standard deviation of 2, a sample size of 90 was required in two groups to know which is a better intervention.

Permuted block randomization was used. Twenty blocks were used with ten allocation chits in each block. The allocation of individuals was blinded, and it was monitored by an independent person who was unaware about groups.

The study protocol was approved by the institutional ethics committee, and then, the study was registered with Clinical Trials Registry-India – CTRI/2011/08/001954.

There were a total of 902 individuals screened for the study, of which 675 were excluded due to reasons mentioned in Figure 1. Interested individuals were invited for an assessment, after which the study purpose and method was explained and informed consent was obtained. Individuals who met inclusion criteria were concealed allocated by another person, who was unaware of study, randomly by block randomization in two groups after which a baseline physical examination was performed and laboratory tests were ordered. There were 112 participants in the yoga group (YG) and 115 in the exercise group at the first stage. At the end of 3 months, there were 101 participants in YG and 99 in the exercise group which was taken for analysis. The reasons of dropout are shown in Figure 1.

Inclusion criteria were type 2 diabetes patients over 20 years of age diagnosed according to the ADA criteria.[14] HbA1c ranges from 7% to 9%, diagnosis of type 2 diabetes for >1 year, stabilized on oral hypoglycemic agents (OHAs) for at least 3 weeks, and no prior exposure to yoga therapy as well as no involvement in a structured exercise program based on self-reporting. Exclusion criteria were individuals requiring insulin, individuals with A1c >9%, hypertension, unstable or underinvestigated coronary artery disease, cancer, severe osteoporosis, or any any other musculoskeletal disorder which may limit administration of

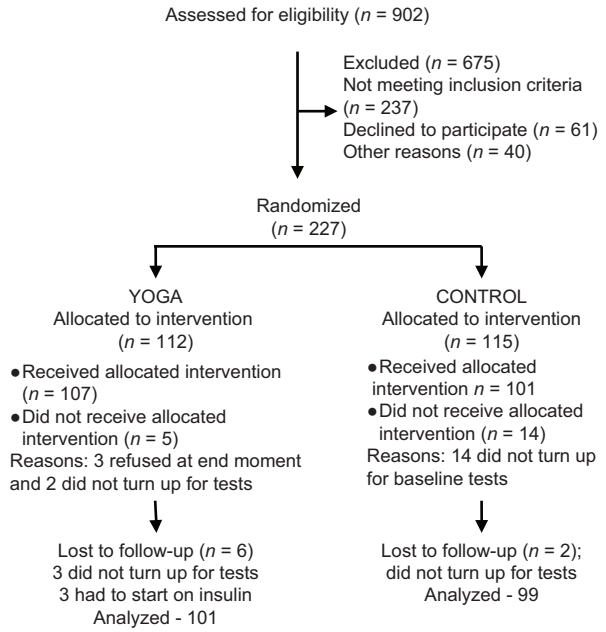

Figure 1: CONSORT flow diagram of participants' allocation, intervention, dropouts, follow-up, and analysis

yoga therapy in type 2 diabetes, individuals with diagnosed cerebrovascular disease, individuals on antipsychotic drug like Selective serotonin reuptake inhibitors (SSRI), aversion of music, already practicing yoga, or music therapy.

Demographic and baseline assessment was done on the 1st day, and intervention was started from the subsequent day. All participants underwent a clinical assessment by supervising physicians. For the exercise group, exercise prescription was done by a qualified physiotherapist at moderate intensity of physical activity as per the ADA standards of care guidelines. It included a structured program that emphasized lifestyle changes that include moderate weight loss (7% body weight) and regular physical activity (150 min/week), with dietary strategies including reduced calories and reduced intake of dietary fat. Diet prescription was done by an expert, and exercise prescription was done by a physiotherapist. The exercise program was supervised for initial 2 weeks. Participants were taught to perform brisk walking at a level ground for at least 150 min/week of moderate-intensity aerobic physical activity (50%–70% of maximum heart rate), spread over at least 3 days/week with no more than 2 consecutive days without exercise. In the absence of contraindications, adults with type 2 diabetes were taught to perform resistance training at least twice per week with an elastic band.[15]

Participants in YG were trained for two subsequent weeks after which they were asked to practice for 3 months. Medications were prescribed by supervising physician as per standard guidelines in both the groups. The medication scores for both the groups are shown in Table 1. On finishing supervised program, all the participants in YG

Table 1: General classes of oral hypoglycemic agents and other drugs taken by participants in all groups during study

Type of drugs	Yoga (*n*=101)	Control (*n*=99)
Metformin	99	98
Sulfonylureas		
Glimepiride	11	09
Glibenclamide	10	13
Alpha-1-glucosidase inhibitor		
Acarbose	09	12
Voglibose	22	20
GLP-1 agonists		
Sitagliptin	05	10
Vildagliptin	07	11
Glitazones		
Pioglitazone	07	11
Statins	45	43
Vitamin supplements	75	77

GLP-1=Glucagon-like peptide-1

were given a "yoga booklet" with instructions written in English and local language Nepali. Both the groups were provided with a "general instruction booklet" which consisted of diet prescription and general information related to disease and standard care.

Adherence to program was ensured by asking all the participants to maintain a "daily log" in a diary to keep a proper record of the activities and lapse. One of the participant attendants was also asked to accompany participant during training and the same countersigned once the participant finished practice at home. All the participants were called over telephone every week in order to know their compliance as well as their difficulty. Participant companion was also contacted at the same time to countercheck. Participants were asked to visit once a month after supervised training while practicing at home. Participants in both the groups were asked to bring their daily log diary which was checked for adherence. YG participants had an 83% adherence to daily log, whereas the exercise group had a 77% adherence. Nonadherence was mainly contributed to sickness, weather conditions, family functions, and unavoidable situations such as attending a funeral ritual. All the groups were tested under similar laboratory conditions.

Yoga was taken from previous literature which has conducted a similar study on effect of yoga in diabetes. Five experts made the final selection and set of *yoga-asana* and *pranayama* to be administered to participants. YG was taught *pranayama* and *yoga-asana* by an instructor daily for initial 2 weeks, and then, they were called regularly at an interval of 1 month for supervision and compliance for 3 months. At the end of 3 months, all outcome measures were repeated. The whole yoga intervention consisted of the following exercises: *Warm-ups*: (starting from the head, working toward the toes. Ten repetitions of each

movement) neck rolls, shoulder rotation, arm rotation, elbow movements, wrist movements, finger movements, waist movements, knee rotation, ankle rotation, and toe movements.

Asanas in standing consisted of (1) *Surya Namaskar* – starting from three turns of each poses being maintained for 10 s and adding each turn every week, (2) *Tadasana* – starting from ¼ min and adding ¼ min every week, and (3) *Trikonasana* – starting from ¼ min for each side and adding ¼ min/week. Sitting asanas were *Vajrasana* – starting from ¼ min and adding ¼ min every week, *Padmasana* – starting from ¼ min and adding ¼ min every week, *Ardha Matsyendrasana* – starting from ¼ min for each side and adding ¼ min/week, and *Paschimottanasana* – starting from ¼ min for each side and adding ¼ min/week. Asanas in prone position consisted of *Bhujangasana* – starting from three turns to be maintained for 10 s and adding one turn every week and *Dhanurasana* – starting from three turns to be maintained for 10 s and adding one turn every week, and supine position asanas were *Halasana* – starting from three turns to be maintained for 10 s and adding one turn every week, *Naukasana* – starting from three turns to be maintained for 10 s and adding one turn every week, and *Shavasana* – starting from 2 min and adding a minute per week.

Pranayama was also given as follows: *Bhastrika Pranayama* - starting from 3 min/day and adding 1 min every month, *Kapalbhati* – 10 min/day, *Anuloma Viloma* – starting from 5 min/day and adding 1 min every month, and *Bhramari* – 5 times a day.

The outcome measures were HbA1c, State-Trait Anxiety Inventory, Beck Depression Inventory (BDI), Diabetes QOL (D-QOL),[16] and ESE.[17]

Statistical analysis

Data were analyzed by SPSS (version 22.0; SPSS Inc., Chicago, IL, USA). Data analysis was blinded. The first normal distribution of samples was plotted and verified by Smirnov–Kolmogorov test. All samples of variables under test were normally distributed, and we decided to use ANOVA with repeated measures followed by *post hoc* analysis with Bonferroni's test; $P < 0.05$ was considered to be statistically significant. ANOVA was used to analyze the changes in outcome variables from baseline to 3 months to know that which intervention caused greater change.

Results

Of 112 participants in YG and 115 in the control group, there were 11 dropouts in YG and 16 in the exercise group. Therefore, 101 participants in YG and 99 in the exercise group were analyzed at the end of 3 months. The flow of patients is illustrated in Figure 1.

The baseline characteristics, demography, and anthropometric measures of both the groups are shown in Table 2. Socioeconomic status was determined as per the Kuppuswamy scale which is a sum of scores summated for education, occupation, and family income. This scoring system has been developed only for Indian population and is well accepted for determining socioeconomic status in India.[18] Majority of the participants in both the groups fall into category of upper-middle and upper classes. Majority of the participants in both the groups have no family history of diabetes, while there is a strong prevalence of tobacco use, smoking, and alcohol consumption in participants across all the groups. Body mass index was 28.2 ± 4.3 in YG participants and 26.3 ± 4.6 in the exercise group participants, which corresponds to overweight category.

The mean blood pressure in YG was 126.0 ± 5.4, 82.1 ± 2.6, and 83.7 ± 2.6 in the exercise group. The mean of blood pressure shows that participants were in prehypertensive group as per the Joint National Committee VIII classification of hypertension. The mean HbA1c was 8.6 and 7.7 in YG and the exercise group, respectively. State anxiety, trait anxiety, and total anxiety were 37.5 ± 6.7, 32.4 ± 6.5, and 69.9 ± 8.2 in YG and 32.0 ± 10.2, 24.7 ± 8.2, and 56.7 ± 12.8 in the exercise group. The level of depression measured by BDI was 23.2 ± 4.3 in YG and 24.8 ± 4.8 in the exercise group.

The self-efficacy level of exercise was 31.1 ± 9.9 and 35.2 ± 9.6 in YG and the exercise group, respectively. QOL was measured by D-QOL developed for diabetes patients of Indian population specifically, and baseline means were 46.9 ± 5.4 and 48.5 ± 8.2. Table 1 shows the generic classification of scheduled drug intake by participants across the groups which were fairly equivalent. Changes in YG and the exercise group from baseline to 3 months have been shown with the help of mean and standard deviation, confidence interval, *F* value, and *P* value in Tables 3 and 4, respectively.

On comparison among the groups, in YG, there was a mean change of 0.47 in HbA1c which was greater than mean reduction of 0.28 in the exercise group with $P < 0.05$. State anxiety reduced by 7.8 and trait anxiety reduced by 4.4 in YG ($P < 0.05$) in 3 months as compared to nonsignificant reductions of 3 and 1 in mean of state and trait anxiety scores in the exercise group ($P > 0.05$). There was a statistically significant reduction in depression score in both the groups, 8.6 in yoga and 4.0 in exercise, which was greater in YG. ESE improved by 19.2 in YG ($P < 0.05$), whereas it improved only 2.2 in the exercise group ($P > 0.05$). QOL improved by 23.7 in YG and 3.0 in the exercise group which was nonsignificant in the exercise group as compared to YG. All mean differences with standard errors are shown in Table 5.

Table 2: Demographic, anthropometric measures and baseline characteristic of the yoga and control groups

Characteristics	Yoga group (101)	Control group (99)	Baseline association
Gender			
Male:female	41:60	49:50	0.001
Age (years)			
Mean±SD	50.3±9.1	49.4±8.7	0.049
Range (years)	23-73	29-72	
Education			
Middle school	11	00	1.000
High school	10	08	0.000
Intermediate	27	20	1.000
Graduate/PG	32	37	1.000
Professional	21	34	1.000
Occupation			
Skilled worker	06	00	1.0
Clerk, shop owner, farmer	30	32	0.000
Semi-professional	30	26	0.000
Professional	35	41	1.000
Income (INR)			
11,817-15,753	05	28	1.000
15,754-31,506	30	27	0.001
≥31,507	67	44	1.000
Socioeconomic status			
Lower middle (11-15)	00	08	1.000
Upper middle (16-25)	77	50	1.00
Upper class (26-29)	24	41	0.01
Duration of diabetes (years)			
1-2	33	36	0.05
3-4	21	36	0.08
5-6	30	18	1.0
≥7	17	09	0.25
Family history of diabetes			
Yes	33	25	0.000
No	68	74	0.000
Tobacco use			
Yes	58	86	0.000
No	43	13	1.000
Smoking			
Yes	68	98	1.0
No	33	01	1.000
Alcohol			
Yes	95	99	0.004
No	06	00	1.000
Height (cm)	160.4±6.9	158.2±6.1	0.000
Weight (kg)	72.1±8.3	65.6±10.9	0.06
BMI (kg/m^2)	28.2±4.3	26.3±4.6	0.039
SBP (mmHg)	126.0±5.4	129.0±5.4	0.000
DBP (mmHg)	82.1±2.6	83.7±2.6	0.000
HbA1c (%)	8.6±0.6	7.7±1.0	0.05
FBS (mg/dl)	319.4±102.8	283.8±102.3	0.07
PPBS (mg/dl)	434.1±108.2	386.6±84.5	1.000
TC (mg/dl)	182.5±29.6	172.6±34.1	1.000
TGs (mg/dl)	208.1±6.0	226.2±6.1	1.00
LDL (mg/dl)	136.9±10.4	145.1±9.4	1.00
HDL (mg/dl)	35.8±9.0	43.1±9.6	1.00
SSI	37.5±6.7	32.0±10.2	0.05
STAI	32.4±6.5	24.7±8.2	1.00
Total anxiety	69.9±8.2	56.7±12.8	0.05
BDI	23.2±4.3	24.8±4.8	0.000
Self-efficacy	31.1±9.9	35.2±9.6	0.02
D-QOL	46.9±5.4	48.5±8.2	0.000

SBP=Systolic blood pressure, DBP=Diastolic blood pressure, BMI=Body mass index, FBS=Fasting blood sugar, PPBS=Postprandial blood sugar, TC=Total cholesterol, TGs=Triglycerides, LDL=Low-density lipoprotein, HDL=High-density lipoprotein, BDI=Beck Depression Inventory, D-QOL=Diabetes Quality of Life, SSI=Spielberger's state anxiety inventory, STAI=Spielberger's trait anxiety inventory

Table 3: Mean changes with standard deviation in the yoga group for variables tested at baseline and 3 months of intervention

Variables	Baseline	CI	3 months	CI	*F*	*P*
HbA1c	8.6±0.6	8.5-8.7	8.1±0.7	8.0-8.2	71.5	<0.05
SSAI	37.5±6.7	36.1-38.8	29.6±9.9	27.6-31.6	95.7	<0.05
STAI	32.4±6.5	31.1-33.7	28.0±7.1	26.5-29.4	19.7	<0.05
Total anxiety	69.9±8.2	68.2-71.6	57.6±10.5	55.5-59.8	121.5	<0.05
BDI	23.2±4.3	22.3-24.0	14.5±2.3	14.0-15.0	531.8	<0.05
Self-efficacy	31.1±9.9	29.0-33.1	50.3±7.0	48.9-51.7	321.5	<0.05
D-QOL	46.9±5.4	45.8-48.0	70.7±7.4	69.2-72.2	502.6	<0.05

HbA1c=Glycated hemoglobin, SSAI=Spielberger's State Anxiety Inventory, STAI=Spielberger's Trait Anxiety Inventory, total anxiety=Sum total of state and trait anxiety as mentioned by Spielberger, BDI=Beck Depression Inventory, D-QOL=Diabetes Quality of Life, Self-efficacy=Exercise Self-Efficacy Scale, CI=Confidence interval

Discussion

On comparison among both the groups, yoga showed better changes and positive differences as compared to exercise not only for glycemic control but also all psychosocial parameters including QOL. Lifestyle modification programs with yoga do show a gradual change in HbA1c higher than exercise alone. A previous study has shown a reduction of 1.2 in HbA1c as compared to 0.04 in the exercise group at the end of 9 months.[19] Another study done by Balaji *et al*. had shown a larger change in HbA1c where type 2 diabetes patients were classified as only on OHA and OHA with insulin compared to a control group. This study also reported reduction in insulin requirements of type 2 diabetes at the end of 3 months of yoga intervention.[20]

There was a reduction in state anxiety by 7.8 at the end of 3 months, whereas trait anxiety reduced by 4.4 with a total reduction in anxiety by 12.2 in YG. This reduction was more than the exercise group which showed a change of 3 in state, 1 in trait, and 4 in total anxiety score. A previous

Table 4: Mean changes with standard deviation in the exercise group for variables tested at baseline and 3 months of intervention

Variables	Baseline	CI	3 months	CI	*F*	*P*
HbA1c	7.7±1.0	7.5-7.9	7.4±1.0	7.2-7.7	18.2	<0.05
SSAI	32.0±10.2	29.8-34.1	28.9±10.2	26.8-31.1	4.7	<0.05
STAI	24.7±8.2	23.0-26.4	23.7±6.0	22.4-25.0	4.8	<0.05
Total anxiety	56.7±12.8	54.1-59.4	52.7±12.1	50.1-55.2	8.7	<0.05
BDI	24.8±4.8	23.8-25.8	20.8±3.2	20.1-21.5	124.7	<0.05
Self-efficacy	35.2±9.6	33.1-37.2	37.4±7.0	35.9-38.9	106.1	<0.05
D-QOL	48.5±8.2	46.8-50.3	51.6±10.0	49.5-53.7	27.0	<0.05

HbA1c=Glycated hemoglobin, SSAI=Spielberger's State Anxiety Inventory, STAI=Spielberger's Trait Anxiety Inventory, total anxiety=Sum total of state and trait anxiety as mentioned by Spielberger. BDI=Beck Depression Inventory, D-QOL=Diabetes Quality of Life, Self efficacy=Exercise Self-Efficacy Scale, CI=Confidence interval

Table 5: Comparison of changes across both the groups in terms of mean difference with standard error

Variables	Yoga group			Exercise group			*F*	*P*
	MD	SE	*P*	MD	SE	*P*		
HbA1c	0.47	0.12	<0.05	0.28	0.13	<0.05	34.4	<0.05
SSAI	7.8	1.3	<0.05	3.0	1.3	>0.05	27.1	<0.05
STAI	4.4	1.14	<0.05	1.0	1.18	>0.05	24.8	<0.05
Total anxiety	12.2	1.70	<0.05	4.0	1.76	>0.05	44.7	<0.05
BDI	8.6	0.45	<0.05	4.0	0.46	<0.05	312.6	<0.05
ESE	19.2	1.35	<0.05	2.2	1.39	>0.05	171.4	<0.05
D-QOL	23.7	1.25	<0.05	3.0	1.3	>0.05	116.7	<0.05

F=Interaction effect computation of ANOVA across groups, HbA1c=Glycated hemoglobin, SSAI=Spielberger's State Anxiety Inventory, STAI=Spielberger's Trait Anxiety Inventory, total anxiety=Sum total of state and trait anxiety as mentioned by Spielberger. BDI=Beck Depression Inventory, D-QOL=Diabetes Quality of Life, Self efficacy=Exercise Self-Efficacy Scale, MD=Mean difference, SE=Standard error

study by Gupta *et al*. has also shown a significant reduction in state and trait anxiety only in 10 days of yoga intervention. This study was performed on 176 patients with different disease conditions where patients with diabetes were also included.[21]

Depression evaluated by BDI reduced by 8.6 in YG and 4.0 in the exercise group at the end of 3 months. In this study, yoga shows a promising effect on depression in type 2 diabetes. Yoga has not been extensively studied for reducing depression in type 2 diabetes, but its efficacy in reducing depression has been studied in other populations.[22,23]

In recent past, studies have shown a strong correlation between stress, anxiety, depression, and pathophysiology of type 2 diabetes,[24] which are interrelated. Control of these psychosocial comorbidities may also show better glycemic control in type 2 diabetes patients by heightening participants' interest in engaging exercise activity, good dietary habits as well as lifestyle changes.

D-QOL improved by 23.7 in yoga and by 3 in the exercise group at the end of 3 months. Effect of yoga on QOL in patients with diabetes has not been studied extensively; however, a study has shown a positive effect of yoga on QOL in patients with diabetes with cardiac complication after 6 months of yogic breathing program in addition to standard care.[25] This yogic breathing program is similar to *pranayama* in our study. Yoga-based program showed higher changes in D-QOL which could not be marked in the exercise group at 3 months. This change is very important and requires lot of discussion. Yoga has greater potential in bringing change in outlook of patients with diabetes toward their life, and it provides wholesome holistic benefits to participants who are not provided by exercise program alone. This also redirects our attention to include yoga as an important tool in lifestyle modification program/standard care guidelines of type 2 diabetes. This scale has been validated in Indian population in middle- and high-income groups. Our baseline data show in Table 2 that most of our participants belonged to this socioeconomic group. Further, higher socioeconomic groups are ready to accept yoga as important lifestyle program, and yoga may be launched as a community program to prevent and control diabetes.

In this study also, participants in all the groups were overweight but not obese. Type 2 diabetes patients have exhibited poor adherence to physical activity and exercise programs and difficulty in initiating lifestyle changes based on diet and exercise. In this study, ESE improved by 19.2 and 3.0 at 3 months in YG and the exercise group, respectively. Yoga is highly promising in improving motivation of patients with diabetes to change, come out of inertia of physical inactivity, and adhere to active, exercise-related program with other necessary lifestyle modifications. A previous study by Yang has also reported a similar change in ESE of patients with diabetes after yoga intervention.[12] This was one of the important assumptions of our study which gets proved that yoga is helpful in changing people positively toward exercise-based program. Further, yoga is an important tool which can be added to exercise programs to get increased benefits without increasing intensity of resistance and aerobic exercise programs, which is one of the reasons for dropout of patients with diabetes from exercise-based programs.

Previous studies have shown positive effects of yoga intervention over these negative affective states such as stress and anxiety.[21] Yoga researches provide a convincing evidence for its effectiveness over autonomic nervous system.[26] Bagchi and Wenger reported that yogic meditation induces the inner relaxation of Autonomic nervous system (ANS) without inducing sleep as well as raising immune levels in the body without exaggerating physiologic manifestation against outside stimuli, thereby providing a balance between body and outside world.[27]

Yoga has a direct effect on optimizing sympathetic hormones such as cortisol and catecholamine secretion, thereby improving parasympathetic activity and reducing metabolic rate.[28] It would not be wrong to state that correlation of diabetes with stress, anxiety, and other psychologic factors are bidirectional and make understanding correlational mechanisms difficult.[29-31] In such a situation, yoga proves to be promising as it helps the body to bring back to balanced state of physical and emotional congruence.

Conclusion and Limitations

Yoga shows better improvement in glycemic control measured by HbA1c, anxiety, depression, QOL, and ESE as compared to exercise alone. These differences are significant, and therefore, yoga must be considered as a community strategy for prevention as well as control of diabetes epidemic across world. Yoga is superior to exercise alone in controlling psychosocial parameters and improving QOL. Yoga increases ESE which improves participant adherence to lifestyle modification programs. Yoga should be primarily adapted as an important intervention in diabetes guidelines along with other lifestyle programs.

This study has few limitations. A major part of program was unsupervised to see the feasibility of program, and adherence was based on participants reporting only. This program was hospital based, and participants were recruited from two tertiary care hospitals of state.

Future research should be directed toward studying the effectiveness of yoga under supervised versus unsupervised program, by increased length of intervention, minute changes in medication scores, and insulin as well as considering it in epidemiologic study design.

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Conflicts of interest

There are no conflicts of interest.

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