Original Article

The Impact of Yoga Intervention on Physical and Mental Health of Adults with Type 2 Diabetes

Abstract

Aim: To assess the impact of a yoga intervention on the physical and mental health of adults with type 2 diabetes. **Methods:** This study was conducted at Madras Diabetes Research Foundation, Chennai, for 6 months. Participants aged 18–65 years, diagnosed with type 2 diabetes mellitus (T2DM), and glycated hemoglobin (HbA1c) levels ranging from ≥7.0% to ≤10.5% were recruited. One hundred and fifty-two participants were randomized in 1:1 ratio to either the intervention or control arm by simple random method. The intervention included structured yoga practice for 35 min, every 2 weeks for a period of 12 weeks, and followed up for 3 months. Participants in the control arm received the standard care for diabetes. Sociodemographic data, anthropometric measurements, and blood samples were collected at baseline and final visit. Standard questionnaires were administered for assessing mental health parameters. **Results:** 53 of 76 (70%) participants from the intervention arm and 70 of 76 (92%) participants from the control arm completed the study. The mean age of the participants was 53 ± 7.5 years. The mean duration of diabetes of the participants was 10 ± 6.9 years. HbA1c showed reduction postintervention, but this was not statistically significant compared to control. The intervention group showed statistically significant improvements in depression, stress, cognitive function, and mindfulness compared to the control arm. **Conclusion:** Yoga is helpful in reducing depression and stress and enhancing mindfulness and cognitive function in patients with T2DM.

Keywords: *Cognition, depression, diabetes mellitus, mindfulness, stress psychological, type 2, yoga*

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Introduction

Type 2 diabetes mellitus (T2DM) is a chronic condition characterized primarily by sustained high glucose levels. More than 537 million adults are affected worldwide and is expected to increase to 783 million by 2045.[1] As per ICMR-INDIAB study, approximately 101 million population are currently living with diabetes in India, of which 90%–95% are classified as type 2 diabetes.[2]

Diabetes not only affects the physical health but also is associated with mental health issues such as stress, depression, cognitive issues, and an impact on quality of life. The mental health issues such as depression and cognitive problems are likely to have a bidirectional relationship and thus warrant an examination of its amelioration.[3] The fundamental management of diabetes is maintaining good glycemic control.[4] Life style changes such as diet, physical activity along with pharmacological treatment alone are not sufficient for good glycemic control.[5-7] Lifestyle changes such as diet and physical activity are at times difficult to achieve and maintain.[8] There is a need to evaluate effective lifestyle strategies for diabetes management like yoga apart from diet, exercise, and medication. Yoga, an ancient Indian practice with over 20 million users, has been practiced in India for several centuries and is a widely accepted lifestyle approach for health and wellness.[9,10]

There are different forms of yoga practices. Yoga incorporates body postures (asanas), breathing techniques (pranayama), and meditation, along with modification of attitudes and behavior-enhancing mental discipline. It has been reported that yoga is beneficial in several lifestyle disorders including diabetes.[11] Yoga as a mind–body-oriented practice needs to be evaluated for its psychological, cognitive impact in addition to biochemical parameters among type 2 diabetes to its application in diabetes care and management.

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There are studies which have evaluated the yoga on type 2 diabetes have focused on glycemic control, quality of life, and some biochemical parameters.[12,13] In addition to adequate glycemic control, there are many psychological issues that are likely to be present in type 2 diabetes which can impact quality of life and long-term life health. Yoga interventions have shown reduction in anxiety, stress, salivary cortisol levels, and depression.[14,15]

Yoga as mind–body-oriented practice has components of self-awareness and present orientation which are likely to enhance cognitive, quality, which can be applied in diabetic care.[16]

In addition to adequate management of glycemic parameters and other biomarkers, the management of psychological issues which have impact on disease course and quality of life needs to be addressed.

Methods

This study was a prospective randomized clinical trial conducted at a tertiary diabetes center, Chennai, from June 2018 to January 2021. The Institutional Ethics Committee at Madras Diabetes Research Foundation approved the study; Ethical Committee approval number - MDRF/NCT/06-01/201, and eligible patients gave written informed consent to enrollment. Participants aged between 18 and 65 years, with documented T2DM, and glycated hemoglobin (HbA1c) levels ranging from ≥7.0% to ≤10.5% were recruited in the study from a tertiary diabetes center at Chennai.

Participants having type 1 diabetes mellitus characterized by the absence of C-peptide, the presence of glutamic acid decarboxylase autoantibodies, and insulin dependence from the time of diagnosis were excluded from the study. Participants with a serum creatinine concentration >132.6 mmol/L (1.5 mg/dL) or liver function impairment (alanine aminotransferase or aspartate aminotransferase levels >2.5 times upper limit of normal range) were excluded from the study. History of anemia or hemoglobinopathy and/or hemoglobin <10 g/dL (<100 g/L) for men and <9 g/dL (<90 g/L) for women, significant alcohol, drug, or medication abuse, currently under psychiatrist's care using antipsychotic or mood stabilizers, or having diagnosed with dementia or bipolar disorder or schizophrenia were excluded from the study. Pregnant or lactating women as well as those who had a recorded cardiovascular disease incidence during the previous 12 months were excluded. Participants with kyphosis, scoliosis, and musculoskeletal disorders were also excluded.

Participants were recruited from the outpatient department, electronic database, and referrals from participants who were part of clinical trials in the past. Potential patients who fulfilled the inclusion and exclusion criteria were informed about the study, and a copy of the informed consent was given to the patient to discuss with their family members and their family physician. After the willingness to participate, written informed consent was obtained in their well-known language. A sample of 76 participants in each group was required for 90% power with α=0.05 to detect a 0.5% treatment difference in HbA1c in the intervention arm. Hence, the total sample size for the study with 10% dropout rate was estimated to be 152 participants.[17]

Assessment parameters

Sociodemographic information such as age, gender, education status and marital status, and details of anthropometric measures were collected at baseline for the purpose of the study. The Chennai Urban Rural Epidemiological Study[18] scale was utilized to measure socioeconomic status. The participants were residents of Chennai. Thus the subjects recruited into the study were naïve to yoga practice. Anthropometry measurements such as height, weight, and body mass index (BMI) were obtained at baseline and final visit using standardized techniques. BMI was calculated using the formula: Weight (kg)/Height squared (m^2). Pulse rate and systolic and diastolic blood pressure were measured using a completely automated device (electronic OMRON machine [Omron Corporation, Tokyo, Japan]), and the measurement will be preceded by at least 5 min of rest for the participant in a quiet setting.

The blood sample was collected at baseline and final visit for assessing biochemical parameters fasting blood sugar (FBS), postprandial blood sugar (PPBS), HbA1c, serum cholesterol, serum triglycerides, low-density lipoprotein (LDL), high-density lipoprotein (HDL), urea, and creatinine. After an overnight fast of at least 8 h, fasting blood sample was obtained.

A venous blood sample was drawn 90 min after a standard South Indian breakfast for estimating postprandial glucose values in individuals already known to have diabetes status. The biochemical parameters were evaluated by different methods.[19] Plasma glucose was measured by the hexokinase method on AU680 Analyzer (Beckman Coulter, USA) using kits supplied by Roche Diagnostics (Mannheim, Germany). Serum cholesterol (cholesterol oxidase-peroxidase-amidopyrine method), serum triglycerides (glycerol phosphate oxidase-peroxidase-amidopyrine method), and HDL cholesterol (direct method-polyethylene glycol-pretreated enzymes) were measured using a Hitachi-912 Autoanalyzer (Hitachi, Mannheim, Germany). LDL cholesterol was calculated using the Friedewald formula. HbA1c was estimated by high-pressure liquid chromatography using the Variant machine (Bio-Rad Turbo 2.0 Hercules, CA., USA).

Standard questionnaires were used to assess mental health, mindfulness, and cognitive function. The Patient Health Questionnaire-9 (PHQ-9) is a 9-item questionnaire designed to screen for depression in primary care and other medical settings.[20]

Total score was calculated by summing up the numbers of all the checked responses under each heading (not at all = 0, several days = 1, more than half the days = 2, and nearly every day = 3). A total PHQ-9 scores of "0–4" indicates none to minimal depression, "5–9" indicates mild depression, and "10–14" indicates moderate depression. "15–19" indicates moderately severe depression and "20–27" indicates severe depression. The Perceived Stress Scale (PSS) is a 10-item questionnaire to measure the level of stress which is reported by the respondents themselves by assessing thoughts and feelings during the previous month.[21] The scores of the questions 4, 5, 7, and 8 were reversed. The scores of each item were summed up to get the total score.

The total score on the PSS can range from 0 to 40 with higher scores indicating higher perceived stress. A total PSS score of "0–13" indicates low stress, "14–26" indicates moderate stress, and "27–40" indicates high perceived stress. The trait Mindful Attention Awareness Scale is a 15-item scale developed to evaluate the differences in the frequency of mindful states of each participant over a period of time.[22] The sum of the 15 items was computed to obtain the score. Higher scores reflect higher levels of dispositional mindfulness.

The Montreal Cognitive Assessment (MoCA) was designed as a brief screening test for mild cognitive impairment (MCI).[23] It takes approximately 10 min to complete. It evaluates visuospatial skills, attention, language, abstract reasoning, delayed recall, executive function, and orientation. The total score on the MoCA test ranges from 0 to 30.

A total MoCA score ≥26 indicates normal cognition. A total MoCA score of "18–25" indicates MCI, "10–17" indicates moderate cognitive impairment, and <10 indicates severe cognitive impairment. The Stroop Color and Word test is a test in cognitive psychology.[24] This test measures response inhibition, that is the ease with which an individual can shift the perceptual set, suppressing a habitual response in favor of changing demand or unusual one. The time taken to read the words (of color words) and naming the colors in which the word is printed (sometimes, color and word do not match) and errors committed are noted.

The Stroop test generates three scores and an interference score based on the number of items completed on each page. Higher scores indicate better performance and less interference with reading ability.

Randomization

Participants were randomized in 1:1 ratio to either the intervention or control arm by simple random numbers. 300 participants were approached, of which 152 participants were screened. The 152 participants were randomized into intervention (n = 76) and control arm (n = 76). The intervention included supervised yoga training for 35 min with various asanas and pranayama techniques [Table 1]. Control group received standard diabetic care and management.[25]

Intervention component

Considering the age, first-time practitioner, the feasibility of sustaining a practice, to enhance physical activation, to induce a state of relaxation, and time availability to practice, specific postures and Pranayama were selected. In addition, earlier experience on the application of yoga for diabetes condition was also used to structure the protocol for practice.[26]

Participants in the intervention group received yoga training once in 2 weeks for 12 weeks. After 12 weeks of intervention, the trained participants were followed up once in a month for 3 months. The yoga session began with 1–2 min of warm-up followed by 20 min of asanas (Tadasana, Parsva Uttanasana, Trikonasana, Apanasana, Jathara Parivrtti, Dvipada Pitham, and Chakravakasana) and ended with a relaxation period which involved pranayama technique. Pranayama technique focused on alternate nostril breathing (Nadishodhana) and cooling breathing techniques (Sitali) [Table 1].

To facilitate and guide home practice, participants were given an audio recording (compact disc [CD]) of the yoga instructions recorded by the yoga instructor, and the participants were advised to practice as by per the instructions in the CD. Regular yoga practice at home was evaluated based on the dairy entries they produced. Yoga practices were supervised as group sessions held once in 2 weeks for 3 months. The yoga instructor examined the dairy for the yoga practice adherence and provided supervised practice. Thus, during the intervention period, compliance was ensured by the yoga instructor. Postintervention assessments were carried out by the research associate at 3 months and 6 months from baseline. Training session for yoga (asanas and pranayama) was 35 minutes. The instruction was delivered to participants in the intervention group once every 2 weeks for 3 months.

Outcome

Change in HbA1c level from baseline to end of 12 weeks and 24 weeks was the primary outcome. Secondary outcomes looked at the mean reduction in the depressive symptoms, stress score, improvement in the cognitive level, and mindfulness.

Statistical analysis

Statistical analysis was performed using IBM SPSS software (Version 27.0, Chicago, IL, USA), STATA (Version 15.1) (StataCorp. Stata Statistical Software: Release 15. StataCorp LLC, College Station, TX, USA, 2017), and Python (Version 3.12.1. Python Software foundation. (n.d.). Python programming language. Available at https://www.python.org). Before analysis, the data were checked for outliers and normality using the Kolmogorov–

Smirnov and Shapiro–Wilk tests. Extreme values were verified against hard copies of the data and corrected as necessary. Continuous variables were summarized as means and standard deviations, whereas categorical variables were presented as frequencies and percentages. A paired *t*-test was used to compare differences in continuous clinical, biochemical, and outcome parameters from baseline to 6 months within both the intervention and control groups.

Difference-in-difference (DiD) analysis was employed to evaluate the changes on outcomes such as depression, cognitive function, stress, and mindfulness by comparing changes over time between the intervention and control groups. $P \leq 0.05$ is considered as statically significant.[27]

Results

152 participants were enrolled and randomized into the study. The socioeconomic status of the study population was lower middle class, and their educational backgrounds included primary school, high school, and graduates. Of the 152 participants, 123 were retained in the follow-up at 6 months, which included 53 of 76 (70%) participants from the intervention arm and 70 of 76 (92%) participants from the control arm with a follow-up rate of 81%.

In addition, the intervention group showed a significant reduction in depression (PHQ-9) and stress (PSS), as well as improvements in mindfulness and cognitive function. The results of this study are statistically significant ($P < 0.05$), as confirmed by the DiD analysis, which shows that the yoga intervention produced better results than the control group. The study had a 19% ($n = 29$) dropout rate, and the main reasons were change of residence and difficulty in adhering to the yoga practice at home [Figure 1].

As shown in Table 2, the DiD analysis between the intervention and control group did not show significant differences in weight, BMI, blood pressure, HbA1c, and lipids.

Table 3, illustrates participants in the intervention group showed reduction in depression as well as in stress scores compared to control group. Similarly, an enhancement of mindfulness in yoga practitioners compared to the control group was observed. The performance on cognitive subtests of MOCA was better in the yoga group, whereas in control subjects, the difference was negligible.

For each participant, the number of words completed and time taken to complete the words (reaction time) of the Stroop test was calculated at baseline and final visit. As shown in Table 4, there was an improvement in the Stroop test in the intervention arm when compared to the control arm at the final visit. However, the DiD analysis between

Table 1: Structured yoga program

Name of the asanas	Number of times
Tadasana	4 Times (2 min)
Parsva Uttanasana	6 at each side (3 min)
Trikonasana	4 times alternatively with 4 breath stay last time (4 min)
Apanasana and Jathara Parivrtti	6 repeat movement (4 min)
Dvipada Pitham	6 repeat (4 min)
Chakravakasana vinyasa	6 repeat (3 min)
Shavasana	8 min
Pranayama	Totally 6 min
Sitali	8 rounds (3 min)
Nadishodhana	8 round (3 min)
	Gradually ratios were increased

Table 2: Comparison of biochemical parameters from baseline to 6 months

Variables	Intervention			Control			Difference-in-difference (SE)[#]	*P*
	Baseline (*n*=76) (0 month), mean±SD	Final visit (*n*=53) (6 months), mean±SD	Absolute difference (effect size)	Baseline (*n*=76) (0 month), mean±SD	Final visit (*n*=70) (6 months), mean±SD	Absolute difference (effect size)		
Weight (kg)	71.8±14.7	71.6±14.8	0.2±0.127	64.7±10.6	64.6±10.8	0.1±0.047	−0.1±0.3	0.708
BMI (kg/m^2)	28.21±4.8	28.21±4.7	0.0±0.009	26.4±2.8	26.3±2.8	0.1±0.082	0.04±0.1	0.713
Systolic blood pressure (mmHg)	123.8±14.4	121.5±11.6	2.3±0.190	123.7±10.6	122.7±11.8	1.0±0.112	−1.3±2.1	0.524
Diastolic blood pressure (mmHg)	78.2±8.5	77.1±7.8	1.1±0.124	76.5±7.6	75.2±7.1	1.3±0.198	0.2±1.5	0.915
HbA1c (%)	8.4±1.2	8.1±1.1	0.3±0.304	8.5±1.0	8.1±1.2	0.4±0.380	0.1±0.2	0.598
Serum cholesterol (mg/dL)	175.4±43.2	172.0±39.587	3.4±0.071	178.6±43.3	165.9±40.2	12.7±0.277	9.3±8.8	0.297
Serum triglyceride (mg/dL)	152.7±71.6	144.4±63.1	8.3±0.112	159.6±102.9	144.7±73.4	14.9±0.138	6.5±17.0	0.699
HDL (mg/dL)								
Male	36.8±6.4	37.6±7.0	−0.8±−0.139	38.6±8.6	41.2±15.2	−2.6±−0.177	−1.9±3.1	0.547
Female	40.4±6.905	43.1±8.9	−2.7±−0.491	44.1±8.3	44.4±10.4	−0.2±−0.032	2.4±1.5	0.105
LDL (mg/dL)	106.6±41.1	104.7±34.8	1.9±0.043	114.7±80.0	94.4±33.3	20.3±0.244	18.5±12.5	0.141

*$P < 0.05$ considered as significant. Effect size calculated using paired *t*-test, [#]Robust standard error. SD: Standard deviation, HDL: High-density lipoprotein, LDL: Low-density lipoprotein, BMI: Body mass index, HbA1c: Glycated hemoglobin

the intervention and control group was not statistically significant.

As shown in Figure 2, dose assessment in the management of diabetes involved determining the appropriate quantities of medications, insulin, and other therapeutic interventions required to achieve and maintain optimal glycemic control while minimizing risks such as hypoglycemia, and this was by assessing the HbA1c every 3 months and fasting and postprandial blood glucose every month; Which was significant in the intervention group. More participants in the intervention group (n = 29) were able to reduce the dose of oral hypoglycemic agents after yoga intervention compared to control group (n = 15), and it was found to be statistically significant ($P < 0.05$).

Discussion

With the increasing burden of diabetes and lifestyle-related disorders in the current scenario, it is important to identify psychosocial factors such as depression, stress, and

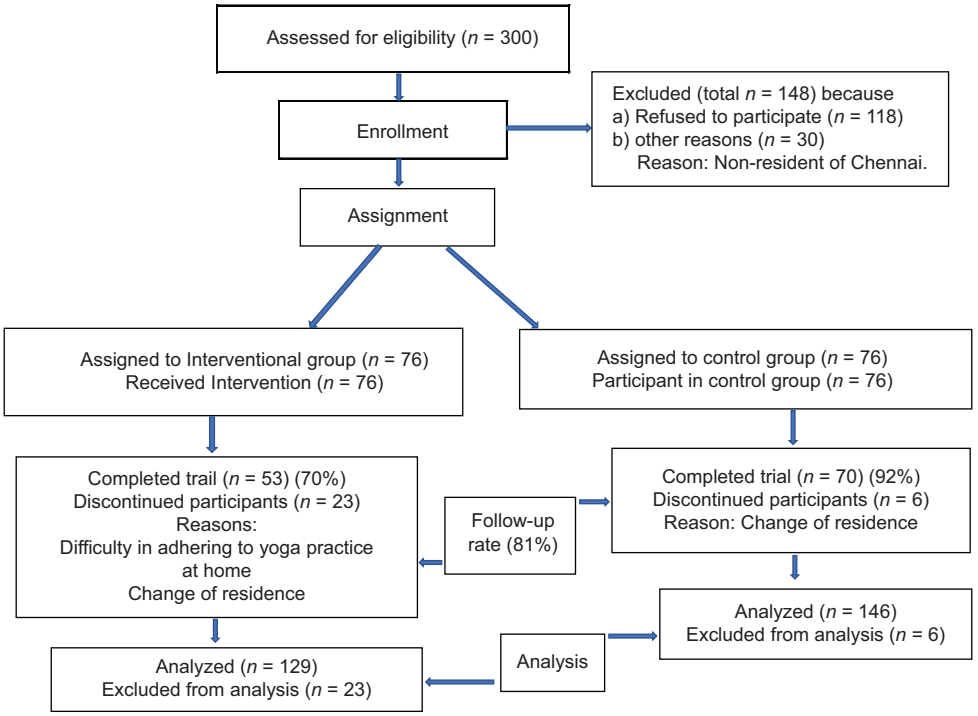

Figure 1: Consort diagram for participant flow

Table 3: Comparison of mental health parameters and cognitive function from baseline to 6 months

Variables	Intervention			Control			Difference-in-difference (SE)#	*P*
	Baseline (*n*=76) (0 month), mean±SD	Final visit (*n*=53) (6 months), mean±SD	Absolute difference (effect size)	Baseline (*n*=76) (0 month), mean±SD	Final visit (*n*=70) (6 months), mean±SD	Absolute difference (effect size)		
PHQ-9	4.6±5.2	1.1±2.0	3.5±0.787	4.2±3.7	5.6±3.8	−1.4±−0.324	−4.9±0.83	<0.001*
PSS	17.5±4.6	15.2±4.0	2.3±0.380	16.7±4.7	18.3±3.5	−1.6±−0.438	−3.9±0.96	<0.001*
MASS	78.2±10.7	81.4±4.5	−3.2±−0.349	78.6±10.1	73.6±8.1	5.0±0.395	8.2±2.06	<0.001*
MoCA	26.9±2.4	27.7±2.4	−0.8±−0.294	24.6±3.6	24.2±3.4	0.4±0.157	1.2±0.49	0.020*

*$P < 0.05$ considered as significant. Effect size calculated using paired t-test, #Robust SE. SD: Standard deviation, PHQ-9: Patient Health Questionnaire-9, PSS: Perceived Stress Scale, MoCA: Montreal Cognitive Assessment, MASS: Mindful Attention Awareness Scale, SE: Standard error

Table 4: Comparison of Stroop test scores from baseline to 6 months among intervention and control group

Variables	Intervention			Control			Difference-in-difference (SE)#	*P*
	Baseline (*n*=76) (0 month)	Final visit (*n*=53) (6 months)	Absolute difference (effect size)*	Baseline (*n*=76) (0 month)	Final Visit (*n*=70) (6 months)	Absolute difference (effect size)*		
Mean Stroop test score	18.5±5.1	21.8±5.3	−3.4±−0.717	14.5±6.8	15.8±5.6	−1.4±−0.228	2.0±1.03	0.056*

*$P < 0.05$ considered as significant. Effect size calculated using paired t-test, #Robust SE. SE: Standard error

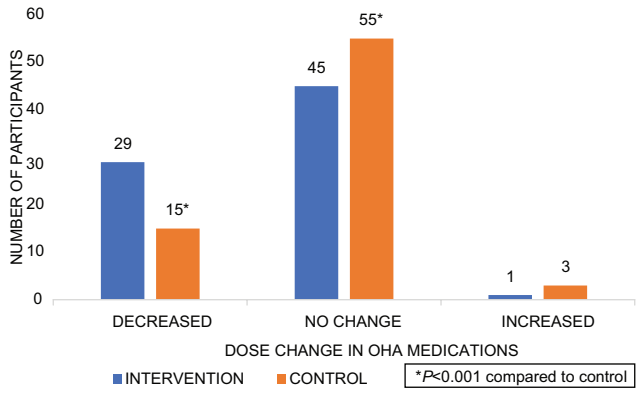

Figure 2: Frequency of dose reduction of oral hypoglycemic agents among control group and intervention group between baseline and 24 weeks

anxiety, which can have a deteriorating effect on diabetes management. The impact of yoga has played a major role in addressing these issues, and it serves as an integrated approach to diabetes care. Our study observed that the yoga intervention group had reported lower levels of depression and stress and improvement in mindfulness. The cognitive performance of the intervened group has significantly improved with respect to visuospatial skills, attention, language, abstract reasoning, delayed recall, executive function, and orientation. The reduced mean reaction time and increase in mean word count in the performance of the intervention group provided the evidence that yoga practices with breath components can improve cognitive alertness. Similar findings were found in the studies by Verma *et al*.[28] and Sunita *et al*.,[29] and the systematic review by Innes and Selfe[30] which showed that yoga reduced stress, anxiety, and depression, supporting the idea that yoga has a beneficial role in managing mental health alongside physical health in people with type 2 diabetes. Studies by Rajani *et al*.[31] and Jali *et al*.[32] reported that yoga improved mental clarity and cognitive function and reduced stress and supported the role of yoga as mind restorative practice which is line with our study.

Our study confirms that it is feasible to conduct a short-term yoga for adult diabetes as a complementary care supported by earlier study, which assessed the feasibility of a 12-week community-based yoga practice. Earlier study by Balaji *et al*. found that there was significant decrease in FBS and PPBS values in both type 1 diabetes and type 2 diabetes who underwent the 3-month yoga and pranayama.[12] Similar findings were found by Malhotra *et al*.,[11,13] Savita,[33] and Acharya *et al*.[34]

Bijlani *et al*.[35] found that the fasting plasma glucose and lipid profile had improved on the last day of the course compared to the first day of the course where yoga was taught for 10 days. Our findings are not confirming these biochemical changes due to yoga intervention. Short-term yoga study of 10 days or 3 months can have an observable change which may not sustain. The current study had a longer time of 6 months duration to evaluate the biochemical changes due to yoga, and these changes were not significant. A study by Sunita *et al*.[29] showed that psychological and mental impact of practicing yoga is characterized by reduced negative thoughts, stress evaluation, and enhanced cognitive alertness. Thus, pointing to the mind-restorative nature of the practice.

Strength

The strengths of the study were assessing the overall impact of yoga on mental health, mindfulness, cognition, and quality of life of diabetes patients apart from assessing only the biochemical parameters. Yoga intervention was well-accepted in a diabetic center by the participants.

Limitation

One of the limitations of the study was that it was conducted in a short duration of only 6 months. Another limitation was that the study period was 6 months duration, but the yoga training was spaced out, and thus, a continuous immersive practice could not be checked, in spite of encouragement for home practice and CD. A continuous supervised practice would have been more beneficial to achieve a reasonable glycemic control. Other factors like dietary adherence was not checked which is likely to have an impact on glycemic control.

Studies with long-term duration of yoga and a continuous monitoring of biochemical correlates with larger sample size are to be conducted to know the physiological impact of immersive practice.

Conclusion

Yoga is a self-empowering activity that people from different socioeconomic backgrounds can do on a daily basis for their general well-being as well as for the treatment of medical disorders. Yoga has proven to be effective in reducing depression and stress, improving cognitive function, and enhancing mindfulness, thus making complementary approach in the management of diabetes.

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Conflicts of interest

There are no conflicts of interest.

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