Original Article

Effectiveness of Adjuvant Yoga Therapy in Diabetic Lung: A Randomized Control Trial

Abstract

Context: Recent studies provide ample evidence of the benefits of yoga in various chronic disorders. Diabetes mellitus is a group of metabolic diseases characterized by chronic hyperglycemia and Sandler coined the term “Diabetic Lung" for the abnormal pulmonary function detected in diabetic patients due underlying pulmonary dysfunction. Yoga therapy may help in achieving better pulmonary function along with enhanced glycaemic control and overall health benefits. **Aim:** To study the effect of adjuvant yoga therapy in diabetic lung through spirometry. **Settings and Design:** Randomized control trial was made as interdisciplinary collaborative work between departments of Yoga Therapy, Pulmonary Medicine and Endocrinology, of MGMC & RI, Sri Balaji Vidyapeeth Puducherry. **Materials and Methods:** 72 patients of diabetic lung as confirmed by spirometry (<70% of expected) were randomized into control group (n=36) who received only standard medical treatment and yoga group (n=36) who received yoga training thrice weekly for 4 months along with standard medical management. Yoga therapy protocol included yogic counseling, preparatory practices, *Asanas* or static postures, *Pranayama* or breathing techniques and relaxation techniques. Hathenas of the Gitananda Yoga tradition were the main practices used. Spirometry was done at the end of the study period. Data was analyzed by Student’s paired and unpaired ’t’ test as it passed normality. **Results:** There was a statistically significant ($P < 0.05$) reduction in weight, and BMI along with a significant ($P < 0.01$) improvement in pulmonary function (FEV_1, FVC) in yoga group as compared to control group where parameters worsened over study period. **Conclusion:** It is concluded from the present RCT that yoga has a definite role as an adjuvant therapy as it enhances standard medical care and hence is even more significant in routine clinical management of diabetes, improving physical condition and pulmonary function.

Keywords: *Diabetic lung, PFT, hathenas, yoga therapy*

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Introduction

Diabetes mellitus (DM) is a group of metabolic diseases characterized by chronic hyperglycemia resulting from defects in insulin secretion, insulin action, or both.[1] Type 2 DM (also known as noninsulin-dependent diabetes) is the most common endocrine and metabolic disorder affecting many organ systems. Its incidence is phenomenally increasing primarily because of increase in the prevalence of a sedentary lifestyle and stress of modern lifestyle and is attributed to the interaction between a genetic predisposition along with behavioral and environmental risk factors. A large number of patients are on lifelong drug therapy imposing a huge economic burden and undesirable side effects of allopathic drugs. It is projected that, by the year 2030, India will have the most number of diabetic patients worldwide.[2] In 2013, about 12% of the world’s adult population (~2.85 crore people) had diabetes and 3.16 crore had impaired glucose tolerance. The curve is going on rising among Indians and is expected to reach 7.9 crores by 2030.[3]

The role of yoga in management and treatment of diabetes has been the subject of curiosity in India as well as abroad.[4] It has been reported that a combination of oral hypoglycemic drugs, insulin, and dietary modification along with exercise can help in such patients.[5] Despite treatment, there is a lacuna in control of blood sugar level which leads to hyperglycemia coupled with further complications such as diabetic retinopathy, neuropathy, or nephropathy.[6] Yoga is an ancient, traditional Indian exercise regimen that has been proved to be beneficial in

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various chronic disorders including asthma, hypertension, psoriasis, arthritis, and diabetes.[7] Skoro-Kondza *et al*. confirmed a small fall in HbA_1c level in yoga group but also stated that it was not sustained due to lack of self-efficacy.[8]

Yoga offers a promising lifestyle intervention for decreasing risk factors related to diabetes by decreasing stress and promoting relaxation as it has been reported to decrease weight related type 2 diabetes risk factors, enhance glycemic control, as well as increase psychological well-being.[9,10] This has been attributed to various mechanisms including increased metabolism of glucose, facilitation of glycolysis, and increased metabolic rate.[11] The evidence in Complementary and Alternative Medicine (CAM) has built up to an extent that the American Diabetes Association has stated that adjuvant therapies may be utilized in cases of diabetes when based on evidence from randomized controlled trials (RCTs).[12]

Sandler reported that abnormal pulmonary function has been detected in diabetic patients due to pathogenesis underlying pulmonary dysfunction in such subjects. He suggested the concept that is today referred to as "diabetic lung."[13] Other studies have studied the association between glycemic state and lung function and reported deterioration in pulmonary function tests (PFT), namely forced expiratory volume in 1st s (FEV_1), forced vital capacity (FVC), and FEV_1/FVC correlated to deteriorating glycemic control.[14,15] Sreeja *et al*. suggested that decreased lung function might be related to poor mechanical properties of lung as lung compliance and elastic recoil of lungs as well as total lung capacity were lower in patients of DM.[16] However, Benbassat *et al*. concluded that there was no correlation between the PFT and duration of DM, presence of microangiopathy, or glycemic control.[17]

Mohankumar and Arulmozhi studied pulmonary complications in elderly diabetics. They reported that in DM total lung capacity, lung volume, and lung compliance are reduced, the central and peripheral airflows are reduced, and acceleration of aging process in pulmonary connective tissue is seen. There is interference with connective tissue cross-links, presence of increased nonenzymatic glycosylation, and modification of alveolar surfactant action. The diffusing capacity for carbon monoxide is reduced because of pulmonary microangiopathy in DM.[18] A study done in 24 noninsulin-dependent DM patients with 40 days of yoga showed improvements in glycemic control as well as pulmonary function (FEV_1, FVC, peak expiratory flow rate, and maximum voluntary ventilation).[19]

Yoga therapy may help in achieving better pulmonary function along with enhanced glycemic control and overall health benefits.[20] Mandanmohan *et al*. compared the effect of slow and fast *pranayama* on PFT and concluded that fast *pranayama* was most effective in improving pulmonary functions.[21]

Hence, it is imperative that adjuvant yoga therapy would improve all study parameters in diabetic lung patients. The importance of this study is that it will pave way for application of yoga therapy in diabetic lung patients and enable determination of prognosis in individuals. As there is a paucity of literature on effects of yoga in diabetic lung, the present study was done to evaluate role of adjuvant yoga therapy in diabetic lung patients.

Materials and Methods

This study was undertaken as an interdisciplinary collaborative work between the Centre for Yoga Therapy, Education and Research (CYTER) of Sri Balaji Vidyapeeth University and the Departments of Pulmonary Medicine and Endocrinology of MGMCRI, Puducherry. Approval was obtained from Institutional Research Council of MGMCRI and Institutional Human Ethics Committee, Sri Balaji Vidyapeeth University. The study was also registered retrospectively on the Clinical Trial Registry-India (CTRI: 2017/11/010479).

Diabetic patients with lung function <70% of predicted values by spirometry (excluding other comorbidities of lung) who were willing to participate and were able to perform techniques in the protocol were recruited for the study along with informed consent. Those with active infections of lungs, especially pulmonary tuberculosis and evidence of complications of diabetes and lungs, were excluded from the study.

A total of 100 diabetic lung patients were assessed for eligibility. Out of them, 72 patients (mean age: 49.6 ± 5.88 years) satisfied that the inclusion criteria were randomized to yoga group (who received yoga therapy training at CYTER thrice weekly for 4 months along with standard medical management with advice on diet) and control group (on standard medical management with advice on diet). Mean age of yoga group (22 males and 12 females) was 51.85 ± 7.60 years while that of control group (25 males and 10 females) was 49.6 ± 5.88 years.

All participants were motivated to do practices at home and maintain a diary to evaluate compliance. Patients were followed up rigorously by weekly telephonic conversations. Thirty-four patients in the yoga group completed the study (two dropped out for personal reasons) and 35 in the control group with one dropout.

Standard medical care for all subjects was provided through the outpatient department of general medicine and pulmonary medicine, and medications included oral hypoglycemic drugs (sulfonylureas/biguanides/glitazones) or insulin for glycemic control was given.

Yoga therapy sessions were conducted at CYTER [Table 1] by trained and qualified yoga therapists. Components of yoga therapy protocol included yogic counseling, preparatory practices, *brahma mudra*, *chandra nadi,* and *bhramari pranayamas*, *shavasana* relaxation, and a series

of 15 *asanas, mudras,* and *pranayamas* collectively known as *Hathenas* in the Gitananda (Rishiculture Ashtanga) Yoga tradition.[22] All of these are traditional yoga practices that enhance awareness and mindfulness of the various lung segments, thus facilitating flow of *prana* into those regions [Figure 1].

Hathenas to increase breath capacity and efficiency in the low chest area (*adham pranayama*) are based on *ushthra asana*, the camel pose, and help expand and stretch tissue in the lower lung region. They recondition the respiratory system to perform conscious and efficient low-chest breathing known as *adham pranayama*. The techniques include *sapurna ushthra asana* (variation 1 and 2), *purna ushthra asana,* and *sapurna shasha asana*. *Hathenas* to increase breath capacity and efficiency in the middle chest area (*madhyam pranayama*) are based on *matsya asana* (the fish posture), and *pranic* energy is stimulated to flow into the mid chest area, thus strengthening and reconditioning intercostal muscles and lung tissue of this region. The techniques include *sapurna* and *ardha matsya asana*, *matsya asana,* and *purna shasha asana*. *Hathenas* to increase breath capacity and efficiency in the upper chest area (*adhyam pranayama*) include *sapurna* and *purna maha mudra*, *bala asana,* and *paripurna shasha asana*. To enhance deep, conscious, and controlled breathing into all sections of the lungs (*mahat yoga pranayama*), *Hathenas* performed from the four-footed *chatus pada asana* include the *sharabha* asana, *chiri kriya,* and *vyagraha pranayama*.[22]

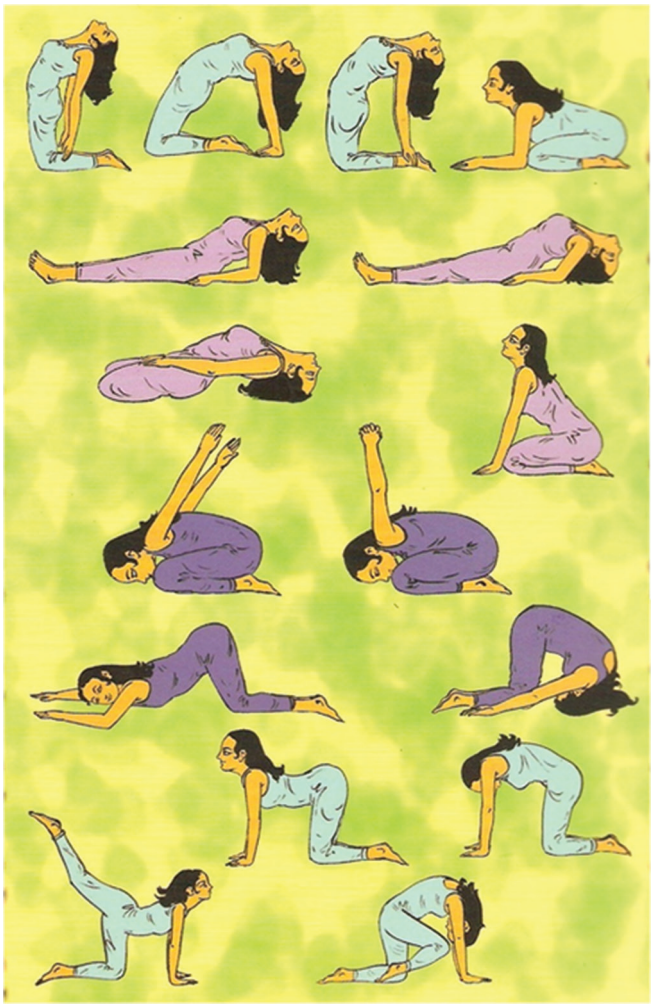

Figure 1: *Hathenas*: a series of 15 techniques of Gitananda Yoga tradition designed to consciously enhance flow of *prana* into different parts of the lungs

Study parameters

Parameters were recorded in all the subjects before and after 4-month study period to assess efficacy of yoga therapy.

Anthropometric data

Data were collected in the yoga hall of CYTER by the auxiliary nursing midwife (ANM). Individual height was measured to the nearest millimeter by the wall-mounted stadiometer and weight measured with a weighing scale (Krups scale). Body mass index (BMI) was calculated by Quetelet's index, which is weight (kg)/height (m)^2 [Table 2].

Pulmonary function tests

EASYONE Spirometer (JK Medical Systems Pvt. Ltd., New Delhi) was used for all PFTs. Tests were done by a qualified technician in an approved laboratory. Subject was seated comfortably in upright position with an erect spine, without bending forward. They were then instructed to take the disposable mouthpiece inside their mouth with lips closed over it to avoid leakage of air while blowing. Nose clip was applied during entire maneuver. Test maneuver was repeated thrice with gap of 3–5 min between each maneuver, and the subject was encouraged to perform at their optimum level applying maximal effort. The best maneuver was considered for analysis.

Table 1: Yoga practices (given thrice a week for 4 months) and their duration

Yoga practices	Duration (min)
Hathenas (15 specialized techniques to enhance lung efficiency consciously as depicted in Figure 1)	30
Chandranadi pranayama (exclusive left nostril breathing with mindfulness)	5
Brahma mudra (movements of the head to four directions: Namely right, left, up and done with the breathing and usage of *akara, ukara, ekara,* and *makara nada*)	5
Bhramari pranayama (bumble bee sound made on the exhalation while using *shanmukhi mudra* to create introspectional awareness of the five senses)	5
Shavasana (supine relaxation of all body parts in sequence from toes to head coupled with slow and conscious deep breathing)	15

Table 2: Comparison of pre, post, delta, and delta% of height, weight, body mass index, forced expiratory volume in 1st s, forced vital capacity, and their ratio (forced expiratory volume in 1st s/forced vital capacity) in yoga and control groups before and after 4 months' study period

	Height	Weight	BMI	FEV_1	FVC	FEV_1/FVC
Yoga group						
Pre	161.64±8.31	68.41±12.48	26.16±4.00	1.79±0.57	2.43±1.18	76.02±12.02
Post	161.58±8.32	64.4±11.60***	24.61±3.64***	2.34±0.79***	2.95±1.25***	78.8±17.45
Delta	−0.05±0.24	−4.01±1.50	−1.55±0.63	0.54±0.77	0.52±1.06	2.77±14.01
Delta%	−0.01±0.01	−0.06±0.01	−0.06±0.02	0.40±0.57	0.33±0.59	0.04±0.18
Control group						
Pre	161.4±9.90	69.4±13.54	26.54±3.68	1.77±0.53	2.15±0.63	77.50±8.94
Post	161.3±9.98	69.8±13.89	26.67±3.58	1.82±0.54	2.30±0.78*	75.99±9.37*
Delta	−0.02±0.17	0.42±2.05	0.12±0.75	0.04±0.18	0.13±0.35	−1.51±3.49
Delta%	−0.01±0.01	0.01±0.03	0.01±0.03	0.03±0.10	0.07±0.15	−0.02±0.05
P						
Pre	0.911	0.754	0.678	0.889	0.251	0.561
Post	0.922	0.854	0.021	0.003	0.016	0.407
Delta	0.541	<0.001	<0.001	<0.001	0.042	0.083
Delta%	0.516	<0.001	<0.001	<0.001	0.022	0.062

Values are given as mean±SD. **P*<0.05, ***P*<0.01, ****P*<0.001 by Student's paired *t*-test for intragroup comparisons and actual *P* values given for intergroup comparison by Student's unpaired *t*-test. BMI=Body mass index, FEV1=Forced expiratory volume in 1st s, FVC=Forced vital capacity, SD=Standard deviation

Changes in all parameters were correlated with compliance to yoga therapy, and correlation of changes in physiological and biochemical parameters with changes in lung function was assessed [Table 2].

Statistical analysis

All data passed normality testing by Kolmogorov–Smirnov test, and hence, intragroup comparisons of pre- and poststudy data were done using Student's paired *t*-test while intergroup comparisons between groups were done using Student's unpaired *t*-test. $P < 0.05$ was considered to indicate significant differences between the means.

Results

The results are given in Table 2 and the delta% changes in FEV_1, FVC, and FEV_1/FVC are shown in Figures 2-4. There was a statistically significant ($P < 0.05$) reduction in weight and BMI in yoga group after 4-month study period. There was significant improvement ($P < 0.05$) in pulmonary function (FEV_1 and FVC) in patients receiving adjuvant yoga therapy.

In the yoga group, FEV_1 and FVC showed improvement after the 4-month study period ($P < 0.001$). The FEV_1/FVC ratio showed no statistically significant change though there was a slight increase in the post values.

In the control group, FEV_1 showed slight increase in the postvalues, which was not statistically significant, whereas FVC increased significantly ($P < 0.05$) due to which there was a corresponding decrease in the FEV_1/FVC ratio also ($P < 0.05$).

Comparison between the groups, showed statistical significance in FEV_1 and FVC ($P = 0.003$ and 0.016, respectively). The delta% values of FEV_1, FVC, and FEV_1/FVC ratio between the yoga and control groups showed significance (<0.001, 0.022, and 0.062, respectively).

Discussion

The present study was planned since there is surge of emerging evidence that yoga as an adjuvant therapy can have significant beneficial effects in diabetic patients. In diabetic patients, lungs are affected by the nonenzymatic glycosylation and this alters the lung connective tissue leading to pulmonary fibrosis and dysfunction. The important aspect of disease-modifying treatment is to have good glycemic control. To the best of our knowledge, this study is the first one of its kinds to assess the impact of yoga as an adjuvant therapy and lifestyle intervention for the derangement of anthropometric indices (height, weight, and BMI) and improvement of pulmonary function (FVC, FEV_1, and FEV_1/FVC).

Both the yoga and control groups were comparable at baseline with respect to characteristics such as anthropometric parameters and pulmonary functions.

Effect of yoga therapy on anthropometric data

Weight and BMI showed significant decrease in yoga group and marginal increase in the control group. Intergroup comparison of the delta changes and delta% changes shows the difference between the pre- and postvalues in yoga and control groups for weight and BMI that had statistically significant difference, which may be attributed to the practices utilizing excess fat deposited peripherally. This finding is in line with findings of other studies attributing such changes to improved metabolic

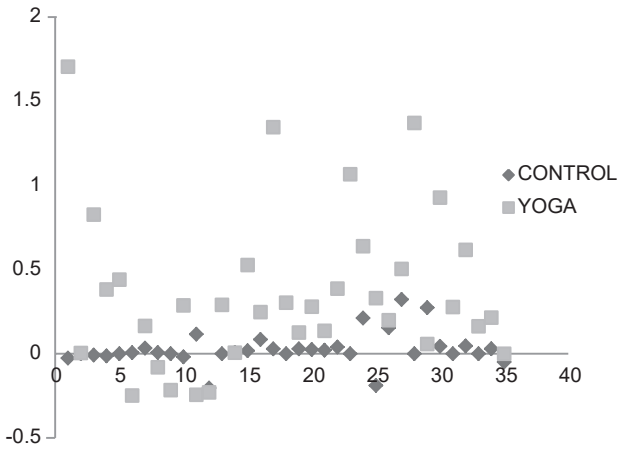

Figure 2: Scatter diagram comparing delta% of forced expiratory volume in 1st s between yoga and control groups

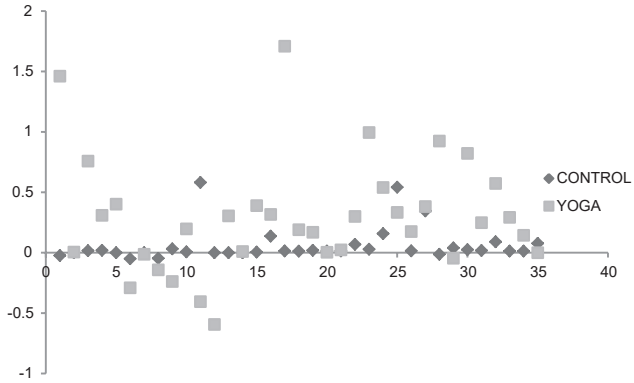

Figure 3: Scatter diagram comparing delta% of forced vital capacity between yoga and control groups

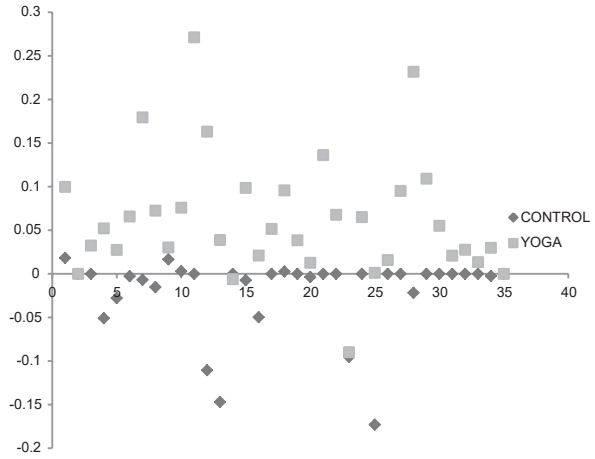

Figure 4: Scatter diagram comparing delta% of forced expiratory volume in 1st s/forced vital capacity between yoga and control groups

function and generalized toning up of musculoskeletal system.[23-26] Some of the practices involving twisting and compression-relaxation actions may be stimulating intra-abdominal organs such as liver and pancreas producing benefits in lipid metabolism.

Yoga has a great potential in preventing and managing chronic diseases and yogic lifestyle can make an appreciable contribution to improvement of health of our masses. Bhavanani stated that yoga has the potential to prevent progression of disease and if started early, maybe even cure it.[27] With multiple collateral benefits and no side effects, yoga can be practiced by ill, elderly, or disabled individuals.[28] It has been suggested that being safe, simple, and economical therapy, yoga should be considered as a beneficial adjuvant for patients of diabetes.[26]

Effect of yoga therapy on pulmonary function

Scientific basis of using yoga as an adjunct therapy in various respiratory disorders such as chronic obstructive pulmonary disease is well established with improvements in lung function, quality of life indices, and bronchial provocation responses coupled with decreased need for regular and rescue medicinal usage.[29,30]

However, few studies have assessed the effects of yoga therapy on pulmonary functions in patients of diabetes that reported decline in lung parameters[31,32] which were attributed to nonenzymatic glycosylation that altered lung connective tissue and led to pulmonary fibrosis and dysfunction.

One of the newer mechanisms postulated for the benefit yoga is that its practices induce a cyclic loading and unloading of body tissues, thus helping maintain health of the extracellular matrix (ECM) that is made up of various proteins, water, and glycosaminoglycans including hyaluronic acid. It has been suggested that yogic practices may be able to temporarily transform the gel-like ground substances of the ECM into a fluid state, thus helping cells, nutrients, and other components of the matrix to move about freely while removing toxins and waste products through the blood or lymphatic system. Physical techniques of yoga as done in this study may induce optimal levels of compression in the ECM and thus help maintain the number and function of fibroblasts which keep the matrix hydrated, open, and strong.[33]

In this study, we found that patients who received adjuvant yoga therapy showed significant improvements in FEV_1 and FVC. FEV_1/FVC ratio showed appreciable improvement though it was not statistically significant. We also found positive improvement in control group in FVC because of which FEV_1/FVC ratio decreased significantly.

Intergroup comparison of the delta and delta% changes showed greater improvement in yoga group in FEV_1 and FVC between groups which may be attributed to nonspecific bronchoprotective or bronchorelaxing effect as reported by Singh *et al*. who also postulated that pranayama and yoga postures may be used to increase respiratory stamina, relax chest muscles, expand lungs, raise energy levels, and calm the body.[34]

Tandon observed improved exercise tolerance following yoga therapy in patients of chronic severe airway

obstruction.[35] Bernardi *et al*. reported that slow yogic breathing maintained better blood oxygenation without increasing minute ventilation and also found reduced sympathetic activation during altitude-induced hypoxia.[36]

Improvement of all lung function parameters in yoga group may be attributed to the regular practice of the *Hathenas* that are specialized yoga techniques aimed at increasing respiratory muscle stamina, lung expansion as well as conscious breath work to relax respiratory process improving lung elasticity and compliance. Pulmonary functions in diabetes patients are usually compromised. Yoga has improved these by various mechanisms which include reduction of obesity, increased oxygenation, opening of airspaces, and recruitment of alveoli. Our results are collaborated by earlier studies reporting similar changes after yoga training in healthy volunteers as well as in those suffering from different conditions.[37,38]

Conclusions

We conclude from the present RCT that yoga has a definite role as an adjuvant therapy along with modern medical management of diabetes. It helps in reduction of weight and BMI which may have an overall beneficial role. Adjuvant yoga therapy induced improvement in lung function clinical parameters including FEV_1 and FVC. As compared to control group who received only medical management, yoga group was found to have statistically significant positive effects in all parameters. As many of these parameters worsened in control group over the study period, addition of yoga as an adjuvant therapy may be said to even be enhancing standard medical care and hence is even more significant in routine clinical management of diabetes.

The results of this RCT provide preliminary evidence that addition of yoga as an adjuvant therapy to a standard medical care can provide additional benefit in terms of improving physical condition as well as pulmonary function. Yoga as a therapy is also cost-effective, relatively simple, and carries minimal risk and hence should be advocated as an adjunct, complementary therapy in our search for an integrated system of medicine capable of producing health and well-being for all. It is expected that the results of this RCT will provide impetus for further in-depth research in evaluating the efficacy of yoga as a complimentary therapy in diabetic patients with special reference to diabetic lung.

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Conflicts of interest

There are no conflicts of interest.

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