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. Hathanas 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 (FEV₁, 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

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 reducing complications of diabetes and improving physical and mental health.

Rajasekar Balaji, Meena Ramanathan¹, Ananda Balayogi Bhavanani¹, Pajanivel Ranganadin², Karthik Balachandran³

1Centre for Yoga Sciences, Aarupadai Veedu Medical College and Hospital, Vinayaga Mission’s Research Foundation, 2Centre for Yoga Therapy, Education and Research, Sri Balaji Vidyapeeth, Departments of Pulmonary Medicine and Endocrinology, 3MGMCRI, Sri Balaji Vidyapeeth, Pillayarkuppam, Puducherry, India

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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 (FEV1), forced vital capacity (FVC), and FEV1/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 airflow 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 (FEV1, 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] Mandannmohan 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.

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 MGMCR, Puducherry. Approval was obtained from Institutional Research Council of MGMCR 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 met and 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. 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, malya 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 vyagragha pranayama.

**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.

| Yoga practices (given thrice a week for 4 months) and their duration | 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 |
| Bhamramari pranayama (humble bee sound made on the exhalation while using shannukhi 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 |
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 \( (<0.001, 0.022, \text{and} 0.062, \text{respectively}) \).

### 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...
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. With multiple collateral benefits and no side effects, yoga can be practiced by ill, elderly, or disabled individuals. It has been suggested that being safe, simple, and economical therapy, yoga should be considered as a beneficial adjuvant for patients of diabetes.

**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.

However, few studies have assessed the effects of yoga therapy on pulmonary functions in patients of diabetes that reported decline in lung parameters 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.

In this study, we found that patients who received adjuvant yoga therapy showed significant improvements in FEV\textsubscript{1} and FVC. FEV\textsubscript{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\textsubscript{1}/FVC ratio decreased significantly.

Intergroup comparison of the delta and delta% changes showed greater improvement in yoga group in FEV\textsubscript{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.

Tandon observed improved exercise tolerance following yoga therapy in patients of chronic severe airway function and generalized toning up of musculoskeletal system. 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.
obstruction.\cite{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.\cite{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.\cite{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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