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Preoperative Rehabilitation in Lung Cancer Patients: Yoga Approach

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Abstract

Lung cancer is one of the leading causes of cancer death worldwide. Surgical removal remains the best option for most tumors of this type. Reduction of cigarette consumption in patients with lung cancer candidates for the surgery could limit the impact of tobacco on postsurgical outcomes. Breathing exercises appear to help combat cigarette cravings. Yoga exercise benefits have been studied in lung cancer survivors, rather than in the preoperative setting. In this study, we have recruited 32 active smokers affected by lung cancer and being candidates for pulmonary surgery. The patients were randomly assigned to two groups: one treated by standard breathing and the other treated by yoga breathing (YB). The groups were evaluated at times T0 (baseline) and T1 (after 7 days of treatment) to compare the effects of the two breathing treatments on pulmonary performance in a presurgery setting. Pulmonary and cardiocirculatory functions have been tested using a self-calibrating computerized spirometer and a portable pulse oximetry device. The findings demonstrate appreciable short-term improvement in lung function assessed by spirometry. We conclude that yoga breathing can be a beneficial preoperative support for thoracic surgery.

Keywords

Active smokers · Breathing exercises · Lung cancer · Pranayama · Preoperative rehabilitation · Pulmonary function · Spirometry · Thoracic surgery · Yoga

1 Introduction

Lung cancer is one of the leading causes of cancer death worldwide. Surgical removal remains the best option for patients with Stage I and II of non-small cell lung cancer (NSCLC) and for selected patients with locally advanced disease (Stage IIIA) (Sisk and Fonteyn 2016). Approximately 20–30% of patients affected by lung cancer, candidates for pulmonary resection, are past or current smokers at diagnosis. The majority of patients who receive a lung cancer diagnosis

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report that they are smokers and want to stop smoking (Morgan et al. 2011). The tobacco dependence is probably the most difficult dependency to break and often requires repeat interventions and attempts to quit (Peddle et al. 2009).

A reduction of cigarette consumption in hospitalized patients with lung cancer awaiting surgery is essential as inhaling of tobacco smoke has a negative effect on postsurgical outcome, due to carbon monoxide and nicotine cigarette content, which increases heart rate, blood pressure, and body's demand for oxygen (Dressler et al. 1996). Nicotine also causes vasoconstriction reducing the blood flow to certain parts of the body (Fiore 2008). Moreover, smoking causes the intrapulmonary small airways to narrow making them more prone to collapse and leading to increased propensity for infection, cough, pulmonary complications, and prolonged mechanical ventilation (Rejali et al. 2005).

Breathing exercises have been proposed as a way of combating cigarette cravings, potentially presenting a low-cost, easily scalable smoking cessation aid. In fact, a focus of attention on breathing and on physical sensations associated with inhalation and exhalation, which partially mimic cigarette smoking, may reduce the urge to smoke. Further, breathing may help smokers to relax and to counteract common withdrawal symptoms (Ngaage et al. 2002). Recent studies have mainly investigated the benefits of yoga exercises in lung cancer survivors (Sisk and Fonteyn 2016), but there is a lack of evidence about the benefit of yoga practice in the lung cancer preoperative setting.

The practice of yoga, meaning "union" the union of mind, body, spirit, and "the oneness of all things," originated about 5000 years ago (Katiyar and Bihari 2006). This practice, as other meditation techniques (Pokorski and Suchorzynska 2018), combines physical posture, breathing exercises, meditation, and philosophy. Yoga is an age-old traditional Indian psycho-philosophical-cultural method of leading one's life, which alleviates stress, induces relaxation, and provides multiple health benefits to the practicing person. It is a method of controlling the mind through the union of an individual's dormant energy with the universal energy. The commonly practiced yoga methods are "pranayama" (deep breathing), "asanas" (physical postures), and "dhyana" (meditation) admixed in varying proportions with differing philosophical background (Katiyar and Bihari 2006).

Recent studies have shown a beneficial role of yoga exercises in the management of health problems, for instance, asthma (Cooper et al. 2003), depressive disorders (Jayatunge and Pokorski 2018), and chronic obstructive pulmonary disease (COPD) (Kaminsky et al. 2017). Yoga breathing produces positive effects in patients with moderate-to-severe COPD, assessed from the improvement of the lung function variables and increments in exercise tolerance and psychological function (Sharma et al. 2005).

Early studies indicate that yoga and above all pranayama are feasible and well tolerated in patients with respiratory pathologies, and these meditation techniques may decrease dyspnea, increase exercise capacity, and improve oxygenation and quality-of-life scores. Focusing on body, mind, and spirit, yoga could be particularly helpful for individuals coping with cancer. In fact, yoga treatment can produce improvements also in the psychological functioning, with less anxiety and depression and increased feeling of hope, control, and self-esteem (Katiyar and Bihari 2006). This kind of psychological enhancement is of values in the face of depression and anxiety oftentimes accompanying cancer (Brown and Kroenke 2009). Further, yoga breathing focuses on the control of respiratory timing. The use of respiratory timing, expressed in seconds, is crucial because it allows the patient to do the best in each breath and allows the physiotherapist to manage the inhalation, air retention, and exhalation in the optimum way. Hatha yoga has been proposed as an adjunctive preoperative or perioperative therapy to improve patients' exercise capacity and to decrease the risk of postoperative pulmonary complications (Shahab et al. 2013). Although preoperative pulmonary rehabilitation has been widely suggested as an intervention to reduce surgical morbidity, an established treatment protocol does not exist (Shannon 2010).

Standard pulmonary rehabilitation uses deep breathing to improve exercise capacity and relaxation. Deep breathing slows respiratory rate, which leads to longer exhalation, better lung emptying, and a reduction in dynamic hyperinflation. Compared to yoga breathing, deep breathing is not involved with respiratory timing changes but rather focuses on breathing mechanics. In contradistinction, the breathing technique of pranayama controls every phase of the breath, which is important for reducing anxiety and withdrawal symptoms before thoracic surgery (Benzo et al. 2012; Holloway and Ram 2004).

Although medical benefits of yoga breathing are recognized, there is an apparent lack of studies on the use of yoga treatment in the lung cancer preoperative setting (Fouladbakhsh et al. 2014). Therefore, this study seeks to compare standard pulmonary rehabilitation with yoga breathing rehabilitation as treatment to improve pulmonary performance in smokers with lung cancer in a presurgery setting.

2 Methods

2.1 Study Design

The study was conducted by the Faculty of Physical and Rehabilitation Medicine of the "G. d'Annunzio" University of Chieti-Pescara in collaboration with the Division of Thoracic Surgery of the "Santo Spirito" Hospital in Pescara (Italy). All the patients gave informed written consent to the experimental procedure, which was in accordance with the latest revision of the Helsinki Declaration for Human Research and with the procedures concerning the privacy protection of subjects participating in biomedical research, as defined by ISO 9001 standards for research and experimentation. The study was approved by the institutional ethics committees.

Thirty-two current smokers (25 males and 7 females, Caucasians) diagnosed with primary NSCLC lung cancer in Stages I and II, candidates for surgical tumor removal that was judged the best curative option, were selected for the study. They were randomly assigned to two groups of 16 participants each: treated by standard breathing (SB) and treated by yoga breathing (YB). The groups were evaluated at two presurgery time points: T0 (baseline) and T1 (after 7-day-long rehabilitation treatment). The inclusion criterion was forced expiratory volume in 1 s (FEV_1) >60% predicted, which gives a low risk of perioperative mortality and respiratory morbidity (Peddle et al. 2009; Licker et al. 2006). The exclusion criteria for both groups were as follows: no eligibility for thorax surgery or metastases, acute diseases or health problems, and comorbidities incompatible with the study protocol such as neurological or cardiovascular diseases.

2.2 Study Procedures and Outcome Measures

All the patients were subjected to medical examination to delineate the characteristics of lung function, the presence and severity of lung cancer, and the eligibility to thoracic video-assisted surgery. This type of surgical approach was chosen since it is associated with a better preservation of clinical condition and a lower requirement for analgesics in the early postoperative period, compared with the standard surgery approach (Karasakia et al. 2009).

Pulmonary function was tested using a Spirolab III (MIR Medical International Research, Roma, Italy), a self-calibrating computerized spirometer that fulfills the criteria for standardized lung function tests. The subject was instructed to take maximum inspiration and blow into the mouthpiece as rapidly, forcefully, and completely as possible. A tight seal was maintained between lips and mouthpiece. Patients performed three tests in each evaluation, and the best of the three was taken into account for further analysis. The following outcome measures were evaluated; all expressed as % of predicted values:

- Forced vital capacity (FVC) – the amount of air that can be forcibly exhaled from the lungs after taking the deepest breath possible. FVC ≥ 80% predicted, calculated from age, height, weight, gender, and ethnic group, was considered the norm.

- Forced expiratory volume in 1 s (FEV_1) – the amount of air exhaled in 1 s, which was taken as a measure of airflow limitation. $FEV_1 \geq 80\%$ predicted was considered the norm.
- FEV_1/%FVC ratio – the Tiffeneau-Pinelli index. The ratio ≥ 70% predicted was considered the norm (Ardestani and Abbaszadeh 2014).
- Peak expiratory flow (PEF) – the maximal flow achieved during the maximum forced expiration started after a full inspiration.
- Peak inspiratory flow (PIF) – the maximum instantaneous flow achieved during a forced inspiration started after a full expiration (Miller 2004).

In addition, peripheral oxygen saturation (SpO_2) of capillary blood hemoglobin and heart rate (HR) were assessed in each patient using a portable pulse oximeter (Nellcor™ Portable SpO_2 Patient Monitoring System PM1 0 N, Medtronic Inc., Dublin, Ireland).

2.3 Intervention Protocol

The YB patients practiced breathing under the supervision of a physiotherapist (Shahab et al. 2013). Treatment consisted of inhalation by first expanding the abdomen and then the chest using one slow and uninterrupted movement, until the maximum possible amount of air was drawn into the lungs, followed by a passively exhalation, accompanied by a feeling of relief and relaxation. The respiratory movement should be a wave-like, continuous abdomen-to-chest motion (Bellomo et al. 2012). Respiration should be accompanied by a sense of calmness. In addition, patients were asked to focus on extending expiration to counteract air trapping in the lungs and to slow expiratory flow. Breathing cycle was timed to 12 s and the timeline of breathing pattern was as follows: 4 s of inspiration, 4 s of air retention, and 8 s of expiration. The procedure was separated into three sets of 10 yoga breaths each, interspersed with 30–60 s pauses between each set, and it was repeated 30 times a day.

The SB patients performed deep and slow breathing. This practice consisted of 30 repetitions of deep breathing, with a deep inspiration exploiting the abdomen and slow expiration through half-closed lips. Akin to the YB group, breathing exercise included 3 sets of 10 deep breaths, interspersed with 30–60 s pauses, and it was repeated 30 times a day.

2.4 Statistical Evaluation

Distribution of data at baseline was assessed with the Shapiro-Wilks normality test. Since the majority of variables did not pass the normality test, nonparametric analysis was employed. Medians of each variable were calculated for both YB and SB groups of patients in preparation for lung cancer surgery and were compared with the Mann-Whitney U test. Differences in the effectiveness of YB and SB were compared at two time points, after (T1) versus before (T0) therapeutic intervention with the Wilcoxon signed-rank test. Correlations between variables were tested with the Pearson method. The level for significance was set at $p < 0.05$. All tests were performed using the R statistical software.

3 Results and Discussion

Table 1 displays the descriptive evaluation of pulmonary function in the YB and SB groups. The patients of both groups were age-matched and also were matched from the clinical standpoint of the existing lung cancer. The inspection of the table shows that the mean values of breathing variables improved across the board in the YB group of patients, as opposed to the SB group where no real improvement could be discerned. The significance of the improvement in the YG, but not SB, group is clearly confirmed in the statistical evaluation of the increases in the values of individual pulmonary function variables from T0 (baseline) to T1 (after 7-day-long treatment) in

Table 1 Evaluation of pulmonary function in the yoga and standard breathing groups of lung cancer patients in preparation for surgery

	Yoga breathing (YB)		Standard breathing (SB)	
	(*n* = *16*)		(*n* = *16*)	
Variables	Mean ± SD	Min – max	Mean ± SD	Min – max
Age (year)	71.3 ± 7.0	59–82	71.8 ± 7.0	58–81
FVC T0 (%)	83.1 ± 15.6	58–113	92.2 ± 16.8	63–121
FVC T1 (%)	95.0 ± 15.6	66–124	94.0 ± 17.2	66–124
FEV_1 T0 (%)	75.7 ± 10.6	62–90	93.1 ± 20.6	64–124
FEV_1 T1 (%)	93.4 ± 16.2	75–125	90.9 ± 20.5	57–121
TIFF T0 (%)	56.2 ± 7.2	42.9–69.4	61.8 ± 8.1	41.8–74
TIFF T1 (%)	60.1 ± 6.7	50.2–72.0	59.2 ± 7.9	35.8–69.3
PIF T0 (%)	35.3 ± 16.1	16–70	41.1 ± 22.9	19–84
PIF T1 (%)	45.8 ± 17.5	23–80	43.4 ± 27.3	10–112
PEF T0 (%)	56.1 ± 20.0	23–86	70.3 ± 27.8	38–125
PEF T1 (%)	69.9 ± 19.2	30–96	65.3 ± 31.2	25–121
HR T0 (bpm)	79 ± 7	73–95	77 ± 5	70–85
HR T1 (bpm)	65 ± 4	56–73	68 ± 2	65–72
SpO_2 T0 (%)	94.8 ± 1.0	94–96	95.9 ± 0.6	95–97
SpO_2 T1 (%)	99.6 ± 1.0	97–99	96.8 ± 0.6	96–98

FVC forced vital capacity, *FEV_1* forced expiratory volumes 1 s, *TIFF* Tiffeneau-Pinelli index, *PIF* peak inspiratory flow, *PEF* peak expiratory flow, *HR* heart rate, *SpO_2* oxygen saturation; T0 (baseline); and T1 (after 7-day-long rehabilitation during presurgery period)

Table 2 Comparison of the significance of changes in breathing variables from T0 (baseline) to T1 (after 7-day long treatment) within the yoga breathing (YB) group and standard breathing (SB) group

	YB -	SB
	T0 vs. T1	T0 vs. T1
Variables	*p*-value	*p*-value
FVC	<0.0001	0.801
FEV_1	<0.0001	0.146
TIFF	0.0130	0.003
PIF	<0.0001	0.820
PEF	<0.0001	0.220
HR	<0.0001	0.0001
SpO_2	<0.0001	0.0020

Abbreviations are same as in Table 1; Wilcoxon signed-rank test for paired data

either group of cancer patients displayed in Table 2.

A significant improvement in FVC and FEV_1 from the baseline T0 to the after treatment T1 in the YB, but not SB, group of patients is also seen when the median values are considered. It is noticeable that the medians of FVC and FEV_1 were lower in the YB than SB group at T0 (Fig. 1), which explains the lack of a significant difference in either variable between the YB and SB group at T1 (Table 3), as the variables increased toward the SB level over time of training while the SB did not. Concerning the PIF and PEF variables, both significantly increased in the YB group, while there was just an increasing trend in the SG group (Figs. 1 and 2, Table 2). Nonetheless, the differences remained insignificant between the two groups (Table 3), which suggest that the improvement was temporary only. Mutual relationships between respiratory variables became strengthened after yoga breathing training, compared with the SB group, as judged from Pearson's correlation coefficients (Table 4), which may be taken as a greater stabilization of the breathing pattern.

Of note, cardiac function, expressed by stabilization of HR and increase in SpO_2, improved significantly from T0 to T1 in both groups (Table 2); the improvements were distinctly greater in the YG group of patients (see details in Tables 1, 2, and 3 and Figs. 1 and 2). The increase in SpO_2 became related with that in FEV_1 after yoga breathing training, the

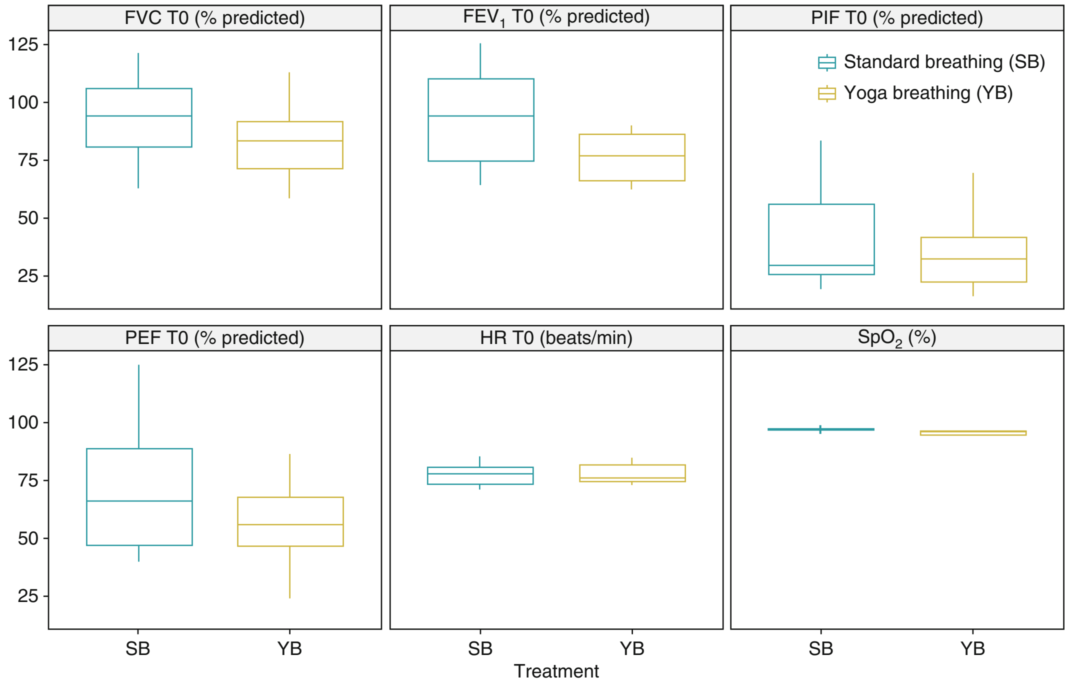

Fig. 1 Box plots of the variables studies at T0 (baseline before treatment). *FVC* forced vital capacity, *FEV_1* forced expiratory volumes 1 s; PIF, peak inspiratory flow, *PEF* peak expiratory flow, *HR* heart rate; SpO_2, oxygen saturation. Median and interquartile range (IQR) is shown; $IQR = Q3 - Q1$. Bars indicate the outliers outside $Q1–1.5IQR$, $Q3 + 1.5IQR$

Table 3 Comparison of the significance of differences in individual breathing variables at T1 time (after 7-day-long treatment) between the yoga breathing (YB) and standard breathing (SB) groups

Variables	*p*-value
FVC T1	0.909
FEV_1 T1	0.748
TIFF T1	0.780
PIF T1	0.497
PEF T1	0.571
HR T1	0.021
SpO_2 T1	<0.0001

Abbreviations are same as in Table 1; Mann-Whitney U test for unpaired data

association not present in the SB group (Table 4). The improvement of cardiac function reported in the present study constitutes an added value to the results of previous studies that have demonstrated a better lung function after the yoga breathing training (Yadav et al. 2009).

The essential findings of this study were that pranayama treatment caused a significant increase in FEV_1 and FVC from T0 to T1 measurement points, i.e., baseline vs. after 7-day-long rehabilitation treatment, in the yoga breathing group of primary lung cancer patients scheduled for thoracic. This increase was absent in the standard breathing group of patients. Respiratory improvement was, in all likelihood, due to slow deep breathing with breath holding and extended expiratory time with the involvement of abdominal expiratory muscles, the features that help relieve gas trapping (Dechman and Wilson 2004). Pranayama type of breathing also reduces dead-space ventilation and work of breathing and refreshes the air throughout the lungs, as opposed to superficial breathing that refreshes the air only at the lung base.

Yadav and Das (2001) have reported an improvement in respiratory functional variables in response to yoga breathing and have attributed the effect to increments in respiratory muscle strength, clearing of respiratory secretions, and using the diaphragmatic and abdominal muscles

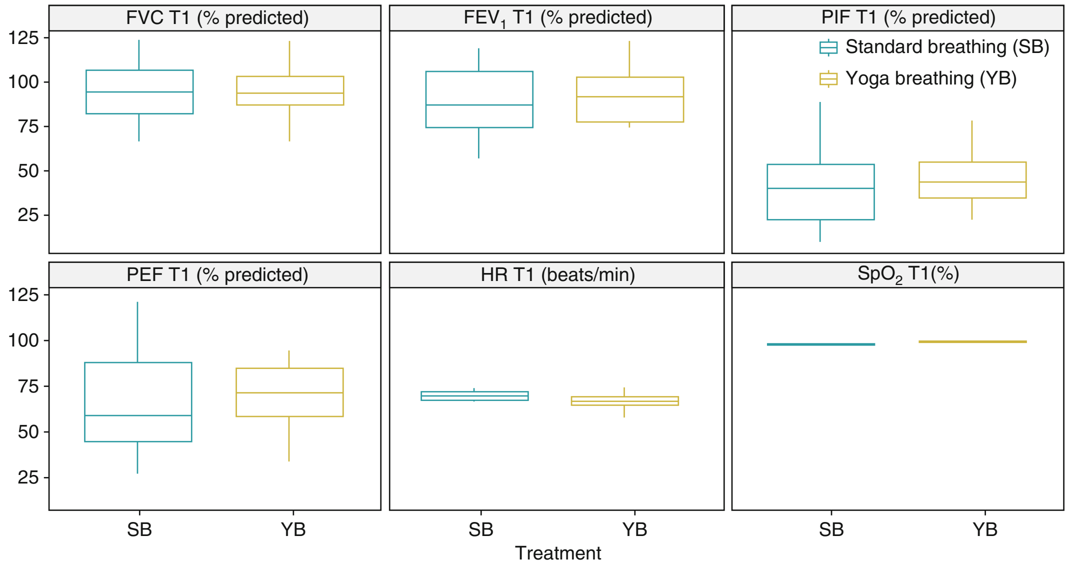

Fig. 2 Box plots of the variables studies at T1 (after 7-day-long treatment). *FVC* forced vital capacity, FEV_1 forced expiratory volumes 1 s, *PIF* peak inspiratory flow, *PEF* peak expiratory flow, *HR* heart rate, SpO_2 oxygen saturation. Median and interquartile range (IQR) is shown; $IQR = Q3 - Q1$. Bars indicate the outliers outside $Q1–1.5IQR$, $Q3 + 1.5IQR$

ancillary respiratory muscles for filling the respiratory structures more efficiently and completely. Moreover, increased strength of respiratory muscles due to yoga breathing enhances ventilation and perfusion of poorly ventilated parts of lungs, thereby improving oxygen delivery to tissues. These effects correct the imbalance of the ventilation-perfusion ratio and consequently may lead to a gain in the PIF value. Likewise, the present findings are in accord with the previous studies that show the PEF improves over the time of 2 weeks of pranayama practice (Yadav et al. 2009).

Pranayamic breathing, characterized by a regular and slow frequency respiration, with long periods of breath retention, is known to affect human physiology. One of the long-term effects of this way of breathing is improved autonomic function consisting of an increase in parasympathetic activity and a blunted sympathetic dominance (Singh et al. 2004). The short-term effects of yoga breathing, on the other hand, include a decrease in oxygen consumption and heart rate and blood pressure. Moreover, it has been suggested that the cardiorespiratory system is normalized through rhythmic breathing exercises, such as slow yoga breathing (Gopal et al. 1973). Thus, this pattern of breathing functionally resets the autonomic nervous system through stretch-induced inhibitory signals and hyperpolarizing currents that propagate through both neural and non-neural tissues, all of which helps synchronize neural elements of the heart, lungs, limbic system, and cortex (Peddle et al. 2009).

A strength of this study lies in the demonstration of a relationship between pranayama practice and improved lung function in active smokers with lung cancer scheduled for thoracic surgery. The study also shows that yoga breathing is superior to standard respiratory training and it is applicable in the primary preoperative setting and pulmonary rehabilitation programs. Yoga breathing training would be particularly useful in the home of patients not included in a formal program of pulmonary rehabilitation. Further, yoga breathing could be a useful aid to smoking cessation. In terms of limitations, the present findings cannot be extended to the postoperative status of patients. Also, further trials in a larger sample of patients should be performed to increase the

Table 4 Correlation coefficients between the pairs of variables studied in yoga breathing group (**a**) and standard breathing group (**b**) of lung cancer patients in preparation for surgery

(a)	Age	FVC T0	FVC T1	FEV_1 T0	FEV_1 T1	TIFF T0	TIFF T1	PIF T0	PIF T1	PEF T0	PEF T1	HR T0	HR T1	SpO_2 T0	SpO_2 T1
Age (yr)	1														
FVC T0	−0.027	1													
FVC T1	−0.207	0.894***	1												
FEV_1 T0	0.115	0.730**	0.697**	1											
FEV_1 T1	0.031	0.813***	0.870***	0.790***	1										
TIFF T0	0.088	−0.553*	−0.409	0.066	−0.159	1									
TIFF T1	0.303	0.011	−0.067	0.277	0.388	0.539*	1								
PIF T0	−0.164	−0.119	0.149	0.030	0.045	0.114	−0.212	1							
PIF T1	−0.240	−0.098	0.128	−0.007	−0.009	0.090	−0.211	0.912***	1						
PEF T0	−0.127	0.748***	0.776***	0.496	0.626**	−0.521*	−0.156	0.408	0.372	1					
PEF T1	−0.314	0.706**	0.804***	0.498*	0.574*	−0.442	−0.319	0.408	0.475	0.804***	1				
HR T0	−0.298	−0.267	−0.091	−0.278	−0.355	0.096	−0.479	0.182	0.327	−0.169	0.192	1			
HR T1	0.191	0.056	0.019	0.082	−0.086	−0.030	−0.200	0.186	0.182	0.222	0.315	0.293	1		
SpO_2 T0	0.365	0.108	0.056	0.422	0.299	0.242	0.306	−0.206	−0.306	−0.129	−0.048	−0.296	−0.148	1	
SpO_2 T1	0.169	−0.290	−0.339	−0.292	−0.548*	−0.060	−0.514*	−0.087	0.016	−0.302	−0.082	0.485	0.487	−0.427	1
(b)	Age	FVC T0	FVC T1	FEV_1 T0	FEV_1 T1	TIFF T0	TIFF T1	PIF T0	PIF T1	PEF T0	PEF T1	HR T0	HR T1	SpO_2 T0	SpO_2 T1
Age (yr)	1														

FVC T0	−0.443	1													
FVC T1	−0.677**	0.865***	1												
FEV_1 T0	−0.258	0.805***	0.723**	1											
FEV_1 T1	−0.349	0.699**	0.745***	0.956***	1										
TIFF T0	0.212	−0.129	−0.050	0.467	0.546*	1									
TIFF T1	0.302	−0.047	−0.107	0.510*	0.557*	0.931***	1								
PIF T0	−0.150	0.370	0.245	0.480	0.443	0.290	0.420	1							
PIF T1	−0.740**	0.367	0.584*	0.127	0.190	−0.316	−0.400	0.409	1						
PEF T0	−0.517*	0.639**	0.629**	0.760***	0.737**	0.310	0.308	0.672**	0.573*	1					
PEF T1	−0.346	0.476	0.443	0.792***	0.792***	0.586*	0.603*	0.618*	0.289	0.913***	1				
HR T0	−0.026	−0.167	−0.127	−0.393	−0.378	−0.402	−0.418	−0.363	−0.190	−0.473	−0.535*	1			
HR T1	0.115	−0.321	−0.185	−0.161	−0.105	0.155	0.056	−0.339	−0.053	−0.115	0.046	−0.335	1		
SpO_2 T0	0.023	0.086	−0.031	0.246	0.204	0.334	0.376	0.114	−0.242	0.130	0.344	−0.022	−0.029	1	
SpO_2 T1	−0.050	0.287	0.350	0.320	0.274	0.168	0.014	0.265	0.214	0.320	0.234	0.024	−0.112	0.280	1

Abbreviations are same as in Table 1, *0.05; **0.01; ***0.001

statistical power of functional data analysis over time and reduce the potential type II error (Maturo and Di Battista 2018; Di Battista et al. 2017). Future direction of research on the effects on lung function of meditative breathing methods should combine manual neuromuscular therapy with yoga respiration as autonomic effects of manual therapy induce reflex rebalancing of the heart and respiratory rates, which modulates the whole body system and thus could help increase the effectiveness of yoga therapy (Barassi et al. 2017; Delli Pizzi et al. 2017).

4 Conclusions

This study contributes to the knowledge about the benefits of pranayama meditative practice on lung function in active smokers affected by lung cancer scheduled for surgery. Although standard breathing exercises are effective to an extent, yoga breathing is an alternative option that may provide the optimum short-term improvement in the lung function. Thus, yoga breathing may become a valid support for the preoperative thoracic surgery preparation. Further, yoga breathing holds a potential to help smokers quit and to improve their quality of life.

Competing Interests The authors declare no competing interests in relation to this article.

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