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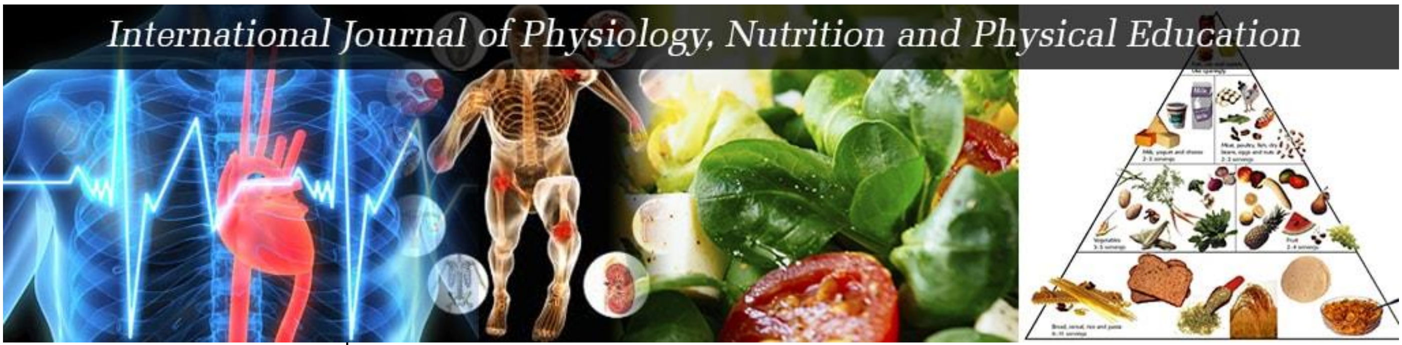

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Effect of yogic intervention on pulmonary function in physically fit individuals: A pilot study

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Abstract
The benefits of any training depend on its duration. Long-term yogic practice will give more health benefits. It is necessary to define a minimum duration for practice to get its maximum effects. The purpose of the study was to identify the duration of yogic intervention requirements to induce significant changes in pulmonary function. The present study was undertaken on six participants (29-34 years of age, height 177 ± 7.21, body mass (74.7 ± 16.38) and BMI (25.31 ± 3.60); mean ± SD). They were undergoing yogic intervention for a total of one hour, five days a week for six weeks. Height, body mass, and pulmonary function test (PFT) involving measurements of Peak Expiratory Flow Rate (PEFR) forced vital capacity (FVC), forced expiratory volume in one second (FEV1), forced expiratory flow, FEF25-75, peak expiratory flow (PEF), maximum voluntary ventilation (MVV) was assessed. Pulmonary function measurements were done in a time point manner i.e., before the yogic intervention, 2nd week, 4th week, and 6th week of yogic intervention. The Difference at different time points was assessed by performing a one-way repeated measure ANOVA test. It was found significant enhancement at the 6th week of yogic intervention with p values like PEFR ($p<0.001$), PEF ($p<0.001$), FEF25-75% ($p<0.05$), FVC ($p<0.01$), MVV ($p<0.001$), FEV1 ($p<0.01$). It was
observed that the six weeks of yogic intervention may be sufficient for significant enhancement in pulmonary function on physically fit healthy individuals.

Keywords: Yoga, minimum duration, FEV, pulmonary function, physically fit individuals, health

Introduction
Respiratory health problems are increasing worldwide. Preventing respiratory diseases is the top priority for decision-makers in the global health sector. As one of the physical and mental interventions, Yoga has the potential to reduce health care utilization (43%) significantly and is considered a key component in the health system and health delivery system of any population [1]. The most beneficial and economical form of exercise for the general public is now the subject of research [2, 3]. Yoga is an ancient Indian science becoming more and more popular worldwide. The word yoga is derived from the Sanskrit root Yuj, which means "union" or bringing together [4]. The physiological effects of yoga practice, including postures like asanas [5], breathing control pranayama [6-9], and meditation [10], have been explored. In recent years, people's scientific interest in yoga has increased significantly. Yoga is not only suitable for yogis; ordinary people can also practice it [11]. The benefits of any workout depend on its duration. Long-term yoga training will bring more health bene due to the lack of empirical support and variability of the recommended dose or duration of yoga training [12]. Several research studies have shown the conducive effect of yoga on PF [13-20] but in different durations. A systematic review and meta-analysis on pulmonary function have established the vital need to do a time- duration study in yoga studies [21]. Positive effects of yoga on people with asthma [22], osteoarthritis [23], cardiac diseases [24], diabetes [25], tuberculosis [26], depressive disorders [27], pleural effusion [28], and COPD [29] were already studied. Hence, clinical patients have not been included in the selection criteria of this article. Data for healthy individuals were included. There is a scarcity of time duration studies where time point measurements are performed to get an apparent effect of yoga to be effective in minimal duration. Therefore, our present study aims to evaluate the impact of yogic training on healthy, physically fit individuals and determine that adequate yoga time is beneficial for becoming significant.

We hypothesized that significant changes in healthy, physically fit individuals could be achieved in less than eight weeks of yogic intervention. We conducted a yogic intervention for six weeks. We recorded the parameters at different time points to know at what time point or at what duration significant changes occur.

Methodology

Participants: Six healthy, physically fit male subjects were enrolled in the study. All participants were between 29-34 years of age, had a body mass index (BMI) of 25.31± 3.60 kg-m2, had normal lung function, did not smoke or take any medications, and were not have previous experience with yoga. None of the participants who suffered from acute and chronic diseases had acute injuries. We also make sure that none of the participants regularly participate in playing a wind instrument or singing as these activities could influence respiration. The participants were briefed verbally, and written information had provided regarding all procedures and possible risks. Each participant signed a written consent before participation. The ethical committee approved the study of the Defence Institute of Physiology and Allied Sciences (DIPAS), Delhi, India (Ref No: IEC/DIPAS/A-4/2).

Study design: The participants underwent yogic intervention for 30 minutes in the morning, five days per week for six weeks, with ambient temperature under the supervision of a certified yoga instructor. Yogic intervention details are given in Table 1.

Study protocol: General anthropometric data and other measurements were recorded in the laboratory. Ambient room temperature and relative humidity varied from 24-260C and 40-50%, respectively. At the onset of this study, baseline parameters, i.e., height weight in kg and pulmonary function, heart rate variability, and bioimpedance parameters, were measured before the yogic intervention, i.e., at the 0 days or before the yogic intervention commenced. A certified yoga teacher gave the yogic intervention. Pulmonary function data were recorded for each participant on one 0day (Before Yoga training/baseline), second week, fourth week, and sixth week of yogic intervention. These recordings were done in the morning at about three h after a light breakfast by the participants.

Anthropometric tests: Height in centimeters and body mass in kilograms were measured using an electronic machine (Delmar, India) with a minor count of 0.1 kg. Measurement was done in a standing erect body posture with minimal clothing. Body Mass Index (BMI) is calculated by the ratio of weight to height in meters squared in kg/m2 units.

Pulmonary Function Test (PFT): Peak Expiratory flow rate (PEFR; L/min) was measured using a peak expiratory flow rate meter (Wright Peak Flow Mini-meter, ARMED, Clement Clarke Int. Ltd, England). A digital spirometer (Pony FX, COSMED, Italy) was used to assess lung function. Subjects were first familiarized with the instrument. Subjects were instructed about maneuvres regarding performing the test. Each participant was also required to make sure no air leaked out of the side of their mouths as they blew out into the spirometer. Measurements like forced vital capacity (FVC), forced expiratory volume in one second (FEV1), forced expiratory flow (FEF 25-75), peak expiratory flow (PEF), maximum voluntary ventilation (MVV) were measured following ATS/ERS standard procedures [30].

Statistical analysis: Data are given as means± standard mean error (SEM). The changes in PF parameters at different time points were assessed by performing a one-way repeated measure ANOVA test. Comparisons were made with initial baseline values and values obtained after yogic training (2nd, 4th, and 6th week); a one-way ANOVA followed by Bonferroni's Multiple Comparison post hoc test was used to determine the effect of yoga on PF parameters. Statistical significance was accepted at $p < 0.05$. A t-test was used to measure the comparison for the BIA data student. Statistical evaluation was processed in GraphPad Prism software.

Results General data

A total of six physically fit individuals in 32 years age group participated in the study. The physical characteristics of the participants of the yoga training are shown in table 2.

Pulmonary function

Data from spirometry measurements depict the effect of yogic intervention duration on PF parameters. There was an enhancement in the PF values, but the enhancement was marginal at the 2nd and 4th weeks of yogic training. At the 6th week values of FVC (figure1), MVV (figure2), FEV1 (figure3), PEFR (figure4), PEF (figure5), FEF25-75% (figure6) found to be significant.

Table 1: Details of yoga package used as pre-post yoga training in the study

Asana/practice, Pranayama & Meditation	Time duration
Yogic vayam	2 minutes
Surya Namaskar	2 minutes
Tadasana	2 minutes
Vriksasana	2 minutes
Kodasana	2 minutes
Adhr chakrasana	1 minutes
shavasana	1 minute
Pawanmuktasana	1 minute
Markatasana	1 minute
Bhujanagasana	1 minute
Ardh-shalbhasana	1 minute
Bhadrasana	1 minute
Vakrasana	1 minute
Mandukasana	1 minute
Kaplabhati	2 minutes
Nadi shodhana	2 minutes
Bhramri pranayama	2 minutes
Guided Meditation	5 minutes
Total Duration	30 minutes

Table 2: Depicts the Anthropometric data of yoga participants who participated in the study

Number of participants N	6
Age (years)	32
Height (cm)	177 ± 7.21
Bodyweight (kg)	74.7 ± 16.38
BMI (kg-m-2)	25.31 ± 3.60

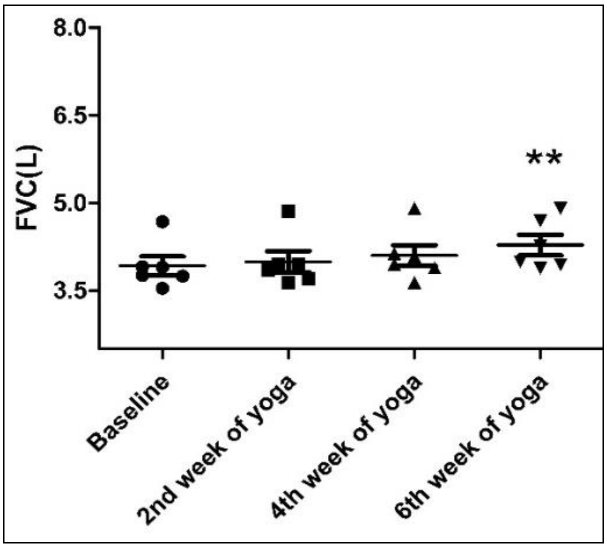
Data are given as mean ± standard error of the mean (SEM). BMI, body mass index

Table 3: Indicated the effect of yogic practice duration on Lung Function Data compared at different time points.

Lung Function Parameters	0 Day (before yoga)	2nd week	4th week	6th week
FEV1 (L)	3.29 ± 0.33	3.37 ± 0.26	3.48 ± 0.33	3.73 ± 0.56**
FVC(L)	3.92±0.39	3.99±0.44	4.10±0.43	4.28±0.43**
PEF	8.83±1.30	9.07 ± 1.41	9.22 ± 1.61	9.56 ± 1.43***
FEF 25-75%	3.64±0.72	3.78±0.52	3.94±0.53	3.97±0.77*
MVV (L/Min)	151.03±15.63	152.33±15.13	157.32 ± 17.78	167.70±21.47***
PEFR L/min	518.33 ±66.46	526.67 ±72.30	540.66±67.82	593.33±85.71***

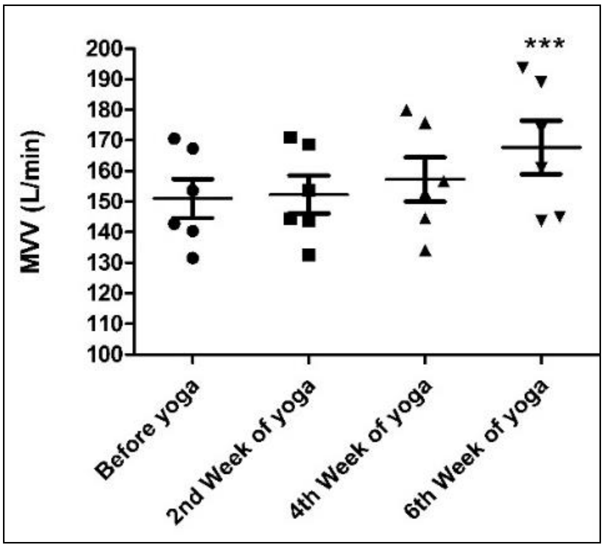
Data are given as mean ± standard deviation. Significances are indicated for the 6th week.
* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

Forced Vital Capacity (FVC), forced expiratory volume in one second (FEV1), peak expiratory flow rate (PEF), Forced expiratory flow FEF25-75, maximal voluntary ventilation (MVV), Peak Expiratory flow rate (PEFR).



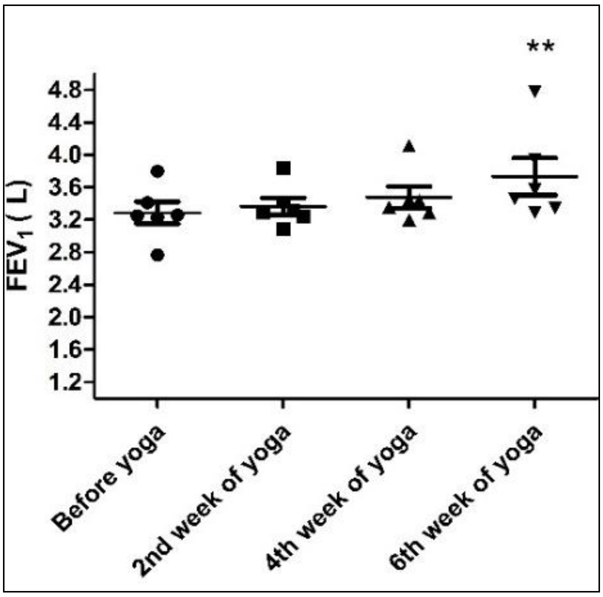
* $p < 0.05$ ** $p < 0.01$*** $p < 0.001$ are indicated for the 6th week.

Fig 1: Changes in forced vital capacity FVC (L) at different time points during yogic training. Values are given as mean ± standard deviation. Significance



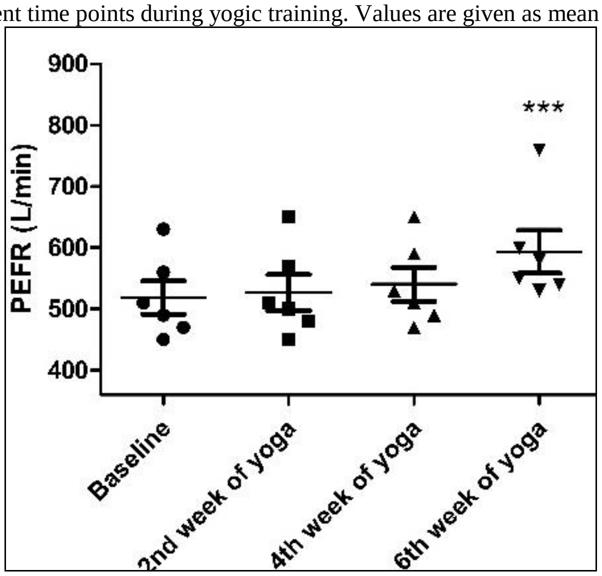
** $p < 0.01$ *** $p < 0.001$ are indicated for the 6th week.

Fig 2: Changes in MVV (L/min) at different time points during yogic training. Values are given as mean ± standard deviation. Significance * $p < 0.05$



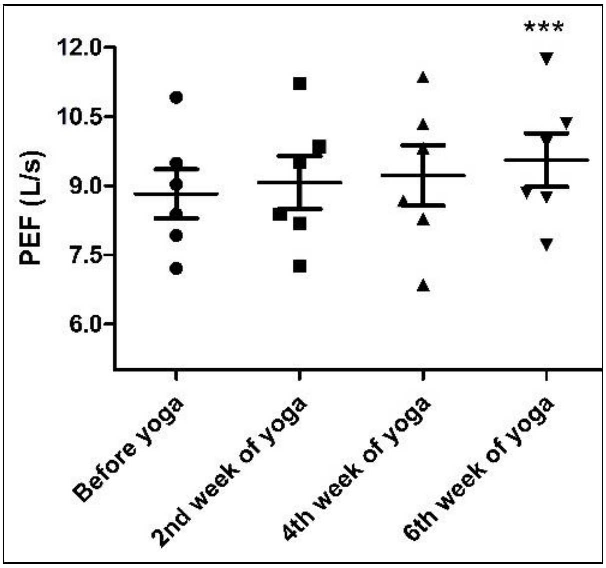
* p < 0.05 ** *p*< 0.01 *** *p*< 0.001 are indicated for the 6th week.

Fig 3: FEV1 (L) changes at different time points during yogic training. Values are given as mean ± standard deviation. Significance



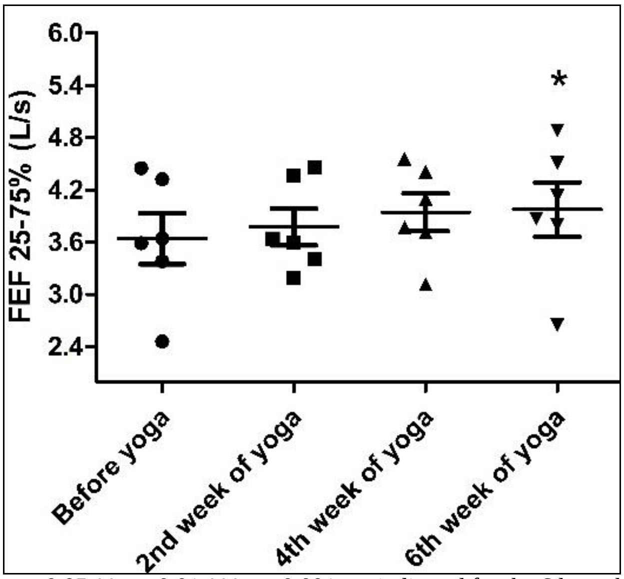
* p < 0.05 ** *p*< 0.01 *** *p*< 0.001 are indicated for the 6th week.

Fig 4: Changes in PEFR (L/min) at different time points during yogic training. Values are given as mean ± standard deviation. Significance



* p < 0.05 ** *p*< 0.01 *** *p*< 0.001 are indicated for the 6th week.

Fig 5: Changes in PEF (L/s) at different time points during yogic training. Values are given as mean ± standard deviation. Significance



* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$ are indicated for the 6th week.

Fig 6: FEF 25-75% (L/s) changes at different time points during yogic training. Values are given as mean ± standard deviation. Significance

Discussion

The present study was conducted to test whether six weeks are sufficient to produce the effect of yoga on physically fit individuals. In our study, all the PF parameters, i.e., FVC (figure1), MVV (figure2), FEV1 (figure3), PEFR (figure4), PEF (figure5), FEF25-75% (figure6) were improved. Although there was an improvement in these parameters at the 2nd and 4th weeks of yoga intervention, significant changes occurred at the 6th week of yogic intervention.

Enhancement of pulmonary functions can be better understood by the effect of yoga on respiration**.** In essence, respiration is semi-involuntary. Without our notice, it is managed rhythmically and autonomously. The medulla oblongata contains a respiratory center that controls the inspiration and expiration of the rhythmic movements. Automatic control depends upon the reflex mechanism of baroreceptors, chemoreceptors, and stretch receptors. The respiratory center is modulated by the carbon dioxide (CO_2) sensed by the chemoreceptors. Respiration rate and depth are enhanced by increasing CO_2 and hydrogen in the blood (plasma). This ample ventilation advances quicker end of CO_2 from the blood. Breath can likewise be controlled somewhat wilfully as indicated by a person's will. The cerebral cortex is responsible for the voluntary control of breathing. Stimulations from the cerebral cortex follow the descending pathways within the vertebral column to the intercostals and, therefore, the diaphragm. One can hold their breath for a couple of moments or minutes. The capacity to hold the breath can increment on the off chance that one practices kapalbhati. Thus, yogic intervention helps the practitioners to control / respiration. The enhancement in the total lung capacity in practitioners by vertical breathing is the main advantage of yogic breathing [31]. The reason may be even the expansion of all the alveoli in both lungs. In yogic training, pranayama incorporates different exercises like bhastrika, kapalbhati (as shown in table 1), which includes forceful inspiration to total lung capacity and forceful expiration to residual volume, and all moves are made through nostrils, which offer opposition or resistance by methods for diminished cross-sectional region and turbulence. Enhanced peak expiratory flows could be disclosed because of better training of the respiratory muscles. As different mental conditions or moods and emotions can influence respiration; a person can control emotions and mental stresses by modifying the breathing pattern. Yogic breathing or the pranayama yoga component can help us achieve it. Through yoga practice, the parasympathetic nervous system activates slow, deeper, and slower breathing. Due to the opening of small airways or alveoli, the lung supply of oxygen-enhanced and lets the lung absorb more oxygen. The abdominal breathing pattern, which explicitly uses the diaphragm, makes the diaphragm and intercostal muscles stronger [32]. In yoga training, slow breathing exercises decrease respiration rate increase tidal volume; thus, improving ventilation efficiency may be due to the alveolar recruitment and swelling, reducing alveolar dead space [33]. Lung expansion close to adding up to lung capacity could be a significant physiological jolt for the discharge of lung surfactant and prostaglandins into alveolar space, which increments lung compliance and diminishes bronchiolar smooth muscle tone separately [20, 34, 35]. With its calming impact on the mind, Yoga can decrease and discharge emotional stresses, therefore pulling back the broncho-constrictor result. The different reflex components that control the respiratory center in the bulbopontine region may be altered by practicing pranayama and creating a strong cortical force, expanding the breath-holding time or diminishing respiratory rate [36]. Shuddhi kriyas are the cleansing process in yoga training that removes impurities from the respiratory tract and enhances pulmonary function [20]. Hence respiratory muscles training and chemosensitive receptor activation through yogic breathing/pranayama can be the possible mechanism for improving pulmonary function (figure7).

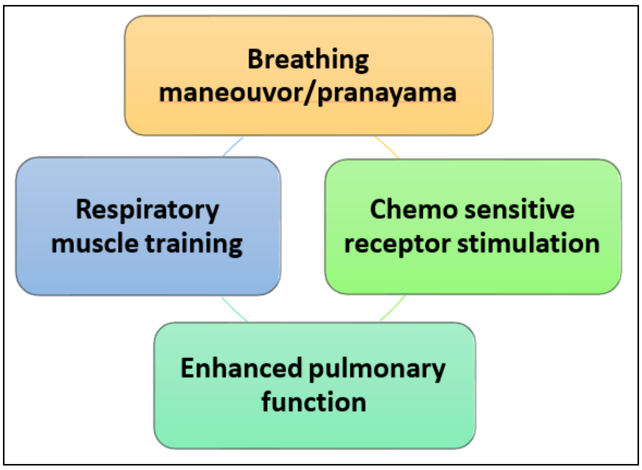


Fig 7: Illustration of a possible mechanism for enhancing pulmonary function through yoga

The limitations of the present study need to be acknowledged and addressed. One of these is the relatively small sample size group in this study. An additional limitation is that this study is a single-arm study without any separate control group. Except for the above limitations, the study has greater applicability in scientific yoga research. Studies of yogic intervention and its therapeutic application over many patients have been accepted and well documented in earlier research. Still, the effects of yogic practice in a time point manner on healthy individuals, as reported in the present study, are very few. The yogic practice affects presently studied parameters, but the exact duration to get significant enhancements is needed. So, the focus of this study, the effect of yoga in a time point manner to be efficient, has greater applicability in yoga and physical activity research. The length and duration of yoga to be effective will depend on age, fitness level, habits like smoking and drinking, injury, any disease, and more. Our findings on healthy individuals of a particular age group will show that yoga can be effective in six weeks.

Conclusion
The study shows that significant enhancement in pulmonary function in physically fit, healthy individuals can be achieved in a minimum of six weeks of yogic intervention.

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