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Research article

EFFECT OF SLOW DEEP BREATHING (6 BREATHS/MIN) ON PULMONARY FUNCTION IN HEALTHY VOLUNTEERS

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ABSTRACT

Objective: We designed this study to test the hypothesis that whether 10 minutes of slow deep breathing have any effect on pulmonary function in healthy volunteers. The main objective was to study the immediate effect of slow deep breathing on Forced vital capacity (FVC), Forced expiratory volume in the first second (FEV_1), Forced expiratory volume percent (FEV_1/FVC%), Peak expiratory flow rate (PEFR), Forced expiratory flow 25-75%($FEF_{25-75\%}$), Maximum voluntary ventilation (MVV), Slow vital capacity (SVC), Expiratory reserve volume (ERV), Inspiratory reserve volume (IRV) and Tidal volume (TV). **Methodology:** Following 5 minutes sitting rest in the lab, Forced vital capacity (FVC), Forced expiratory volume in the first second (FEV_1), Forced expiratory volume percent (FEV_1/FVC%), Peak expiratory flow rate (PEFR), Forced expiratory flow 25-75% ($FEF_{25-75\%}$), Maximum voluntary ventilation (MVV), Slow vital capacity (SVC), Expiratory reserve volume (ERV), Inspiratory reserve volume (IRV) and Tidal volume (TV). The same parameters were recorded following Regular Spontaneous Breathing (RSB) and Slow Deep Breathing (6 breaths/min). **Results and Conclusion:** There was significant increase in FVC ($p<0.0059$), FEV_1 ($p<0.026$), PEFR ($p<0.02$), $FEF_{25-75\%}$ ($p<0.0006$), SVC ($p<0.002$), ERV ($p<0.033$), IRV ($p<0.025$) and TV ($p<0.0001$) after practicing SDB compared to RSB. Slow deep breathing may be used as a non-pharmaco therapeutic and safe modality, it can be used as an effective lifestyle adjunct to medical treatment to reduce drug dosage and improve quality of life of the patients.

Key words: Pulmonary function, Regular Spontaneous Breathing (RSB), Slow Deep Breathing (SDB).

INTRODUCTION

Yoga has been originated in 5000 BC, it is an ancient philosophical and religious tradition. Because of increasing incidence of lifestyle diseases such as obesity, hypertension, cardiovascular diseases, and diabetes mellitus due to urbanization and faulty lifestyle and psychological stress, yoga is incorporated into modern medicine since few decades [1].

Pranayama is the science of breathing[2]. As it is a form of physiological stimulus, the regular

practice of Pranayama is a form of adaptation to a repeated stimulus. Breathing is the only autonomic function that can be consciously controlled. It helps in bringing the involuntary nervous system i.e; sympathetic and the parasympathetic nervous system into harmony[3]. The practice of breathing exercise increases parasympathetic tone, decreases sympathetic activity, improves cardiovascular and respiratory functions by affecting oxygen consumption, metabolism and skin resistance[4,5].

Slow deep breathing like pranayama reduces dead space ventilation, renews air throughout lungs, in contrast with shallow breathing which renews air only at the base of the lungs. Pranayama, the fourth step of astang yoga is an important component of yoga training[6]. Training effect of different pranayama techniques and deep breathing on pulmonary functions has been reported extensively. Pranayama is a method of breathing and chest expansion exercise, which has been reported to improve respiratory function in health and respiratory disease[7]. The literature search through PUBMED central and other search engines showed scanty data on acute/immediate effects of deep breathing and pranayama on pulmonary functions. Even a few successive episodes of deep breathing may influence the lung dynamics. The role of deep breathing on release of surfactant and consequent change in pulmonary compliance, and other lung functions has been extensively studied both in cultured pulmonary epithelial cells, in isolated and intact lungs of many different animals[8] . But whether the same phenomenon occurs in human, and whether that can alter any of the parameters of pulmonary function has not been studied in detail.

In our literature search, we found only effects of at least a short term practice extended over a period of a few days to weeks of pranayama rather than acute effects of pranayama. The pulmonary function test (PFTs) is a valuable tool for evaluating the respiratory system and is a simple screening procedure which can be performed by using standardized equipment to measure the lung function. Keeping this in mind the present study was designed to test the hypothesis that whether 10 minutes of slow deep breathing have any effect on pulmonary function in healthy volunteers. The main objective was to study the immediate effect of slow deep breathing on Forced vital capacity (FVC), Forced expiratory volume in the first second (FEV_1), Forced expiratory volume percent (FEV_1/FVC%), Peak expiratory flow rate (PEFR), Forced expiratory flow 25-75%($FEF_{25-75\%}$), Maximum voluntary ventilation (MVV), Slow vital capacity (SVC), Expiratory reserve volume (ERV), Inspiratory reserve volume (IRV) and Tidal volume (TV).

MATERIALS AND METHODS

This is a cross-sectional study undertaken by the Department of Physiology, Pulmonary Function Testing Laboratory, Narayana medical college (NMC), Nellore (A.P), India. After obtaining approval of the Institutional Ethics Committee (IEC), pulmonary function tests were conducted in 30 healthy volunteers.

Inclusion criteria: Age group of 18 to 40 years; age , BMI matched students and residents of NMC. The subjects of both genders were included.

Exclusion criteria: Subjects with a past history of smoking, hypertension, respiratory diseases, chest wall injuries, congestive cardiac failure, kyphoscoliosis and who are already trained in yoga and exercise were excluded from the study.

Methodology: The volunteers were properly explained about the objectives, methodology, expected outcome and implications of the study and written informed consents were obtained from them. They were instructed to report to PFT lab of Physiology department at about 9 A.M. Volunteers are trained to Slow deep breathing (SDB) by experienced yoga teacher from Narayana Yoga and Naturopathy college, and volunteers also get familiarized with our research lab and procedure of pulmonary function testing.

Following 5 minutes sitting rest in the lab, their pulmonary functions were assessed by computerized spirometer (Spirowin Version 2.0 of Genesis Medical systems pvt Ltd) which gives ERS-93 predicted values at BTPS conditions[9]. After preliminary trials, a baseline reading was taken followed by a reading after practicing regular spontaneous breathing (RSB) for 10 minutes. Volunteers followed the instructions given by qualified and experienced yoga teacher for slow deep breathing of 6 breaths/min for 10 mins. After practicing slow deep breathing (6 breaths/min) for 10 min, the test was performed three times and the best reading was considered. The tests were performed with subjects in the standing position[10,11].(Explanation: A sitting position was used at the time of testing to prevent the risk of falling and injury in the event of a syncopal episode, the PFT can also be performed in the standing position.The test is performed in standing position as the ventilatory capacities are greater in standing position than in sitting or lying posture, change in posture will change the ability to carry out physical effort and ventilatory capacity of the lungs. As the procedure of these tests are effort dependent the subjects are asked to perform the test in standing position because the diaphragm descends and the capacity of thoracic cage increases in erect posture). During the procedure, the subjects inhaled deeply and then exhaled with maximum effort as much as possible into the mouthpiece for FVC test. The subjects inhaled deeply and exhaled slowly and completely as much as possible, this was repeated for 3-4 times followed by normal respiration for SVC test. The following parameters were recorded: Forced vital capacity (FVC), Forced expiratory volume in the first second(FEV_1), Forced expiratory volume percent(FEV_1/FVC%), Peak expiratory flow rate(PEFR), Forced expiratory flow 25-75%($FEF_{25-75\%}$), Maximum voluntary ventilation(MVV), Slow vital capacity(SVC), Expiratory reserve volume (ERV), Inspiratory reserve volume (IRV) and Tidal volume (TV).

RESULTS

The data were expressed as mean ± SD, were analyzed using the GraphPad Instat Version3.0 for Windows, GraphPad Software. The Gaussian distribution was determined. Normally distributed data were tested by the one way ANOVA and post-hoc analysis was done with Tukey. Non-normally distributed data were tested with Krusukal-Wallis and post-hoc analysis was done with Dunn. A Pvalue of $P<0.05$ was considered significant.

Table 1 shows the anthropometric parameters of the subjects. Table 2 shows the respiratory variables like lung capacities, volumes and flow rates at baseline (BL), after Regular spontaneous breathing (RSB) and after Slow deep breathing (SDB). There was a significant increase in FVC ($p<0.0059$), FEV_1 ($p<0.026$), PEFR ($p<0.02$), $FEF_{25-75\%}$ ($p<0.0006$), SVC ($p<0.002$), ERV ($p<0.033$), IRV ($p<0.025$) and TV ($p<0.0001$) after practicing SDB compared to RSB and BL values.

Table 1. Anthropometric parameters

Parameter	Mean ± SD
Age (Yrs)	20.8 ± 4.41
Weight (Kgs)	54.6 ± 11.8
Height (m)	1.62 ± 0.09
BMI (kg/m^2)	20.6 ± 3.28
BSA (m^2)	1.563 ± 0.20

Table 2. Comparison of Respiratory variables between BL, RSB and SDB

Parameter	Mean ± SD			P value
	BL	RSB	SDB	
FVC(L)	2.25 ± 0.45	2.52 ± 0.56	2.72 ± 0.62	0.0059*
FEV_1(L)	1.92 ± 0.54	2.17 ± 0.52	2.30 ± 0.54	0.026*
FEV_1/FVC%	86.53± .16	86.23 ± 9.89	85.05 ± 8.14	0.80
PEFR(L/S)	3.85 ± 1.29	4.16 ± 1.38	4.53 ± 1.07	0.02*
FEF25-75% (L/S)	2.05 ± 0.70	2.52 ± 0.69	2.73 ± 0.64	0.0006*
SVC (L)	3.39 ± 1.77	4.09 ± 2.58	5.36 ± 3.11	0.002*
ERV (L)	1.16 ± 1.14	1.54 ± 1.48	2.17 ± 2.13	0.033*
IRV (L)	1.69 ± 1.42	2.36 ± 2.24	3.11 ± 2.74	0.025*
TV (L)	0.66 ± 0.40	0.96 ± 0.45	1.22 ± 0.45	0.0001*
MVV (L)	67.64±20.82	73.99 ± 23.22	81.16 ± 22.9	0.069

BL: Baseline, RSB: Regular spontaneous breathing, SDB: Slow deep breathing, FVC: Forced Vital capacity, FEV_1 : Forced Expiratory Volume in 1 sec, PEFR: Peak Expiratory Flow rate, $FEF_{25-75\%}$: Forced Expiratory Volume, SVC: Slow vital capacity, ERV: Expiratory Reserve Volume, IRV: Inspiratory Reserve Volume, TV: Tidal Volume and MVV: Maximal Voluntary Ventilation. * signifies $p< 0.05$ which shows values are statistically significant.

DISCUSSION

As yoga aims at the perfection of the body and mind, it is natural to ask whether the progress towards perfection reflects objective reproducible changes in physiological variables. Breathing is the only autonomic function that can be consciously controlled and it is the key in bringing the sympathovagal harmony.

From the results (table 2) it is evident that immediate effect of slow deep breathing showed significant improvement in FVC, FEV_1, PEFR, $FEF_{25-75\%}$, MVV, SVC, ERV, IRV and TV. FEV_1 is the volume of air that is exhaled in the first second during FVC manoeuvre. It is useful to detect generalized airway obstruction. FEV_1/FVC% is the volume of air expired in the first second, expressed as percentage of FVC. It is a more sensitive indicator of airway obstruction, than FVC or FEV_1 alone. $FEF_{25-75\%}$ is the average flow rate during middle 50% of FVC. It indicates patency of the small airways. $FEF_{25-75\%}$ depends on non-bronchopulmonary factors like, neuromuscular factors and mechanical equipment factors of inertial distortion of the lungs. PEFR and $FEF_{25–75\%}$ are the first parameters to decline on many respiratory diseases. Any practice that increases PEFR and $FEF_{25–75\%}$ is expected to retard the development of COPD's. The immediate effect of slow deep breathing practice also alleviates PEFR and $FEF_{25–75\%}$ and other lung function parameters .

Our findings are consistant with Bal et al., Upadhyay et al., Nayar et al., Joshi et al. And subbalakshmi et al[12-16]. Most of the study results are based on the practice of slow deep breathing for a few weeks to months but the immediate effect of it is less studied.

Physiological changes occurring during different phases of SDB are:

Inspiration phase[14, 16]:

During the inspiration the lungs are expanded considerably and the walls of alveoli are stretched maximum. After a particular degree of stretching, the stretch receptors situated in the alveolar walls are stimulated. In normal

breathing, during this stage or even before this, the inhibitory impulses would be sent to the inspiratory center and the phase of exhalation would have been started in a reflex. But as we continue the phase of inspiration with strong voluntary control, the normal stretch reflex is inhibited, no exhalation is possible. The chest continues to expand under neural control. The stretch receptors are thus trained to withstand more and more stretching. During this phase the intra-pulmonary pressure is also raised and the diaphragm does not move freely. Therefore the alveoli in the lung apices are filled with air. Inspiratory capacity is used for this phase. This has a beneficial effect on the gaseous exchange, as it works efficiently throughout the day. This is not just a mechanical prolongation of inspiration but it is done with full concentration.

Expiration phase[14,16]:

This phase is a voluntary controlled expiration as compared to normal. The duration, force, ventilation and the flow of air are controlled. The expiratory force is reduced and the air is allowed to escape slowly. This helps in prolongation of expiration, reduce the force of outgoing air. This phase has utilized ERV for expiring completely before initiating the next cycle. In this phase the intra-pulmonary pressure slowly reduces and the alveoli are gradually deflated. By this time when one is expiring slowly, the percentage of carbon dioxide is still increasing in the blood and the chemo receptors in the medulla are trying to inhibit expiration and to start inspiration phase by stimulating the inspiratory center. The peripheral chemo receptors also try to bring about inspiration in a reflex manner as they are sensitive to the lower oxygen concentration in the blood.

Slow, deep breathing also resets the autonomic nervous system through stretch-induced inhibitory signals and hyperpolarization currents propagated through both neural and non-neural tissue which synchronizes neural elements in the heart, lungs, limbic system, and cortex[4]. It is thought that voluntary deep breathing dynamically modulates the autonomic nervous system by generation of two physiologic signals: 1) SDB increases frequency and duration of inhibitory neural impulses by activating stretch receptors of the lungs during inhalation above tidal volume (as seen in the Hering Breuer's reflex). 2) SDB increases generation of hyperpolarization current by stretch of connective tissue (fibroblasts) localized around the lungs. It is recognized that inhibitory impulses, produced by slowly adapting receptors (SARs) in the lungs during inflation, play a role in controlling typically autonomic functions such as breathing pattern, airway smooth muscle tone, systemic vascular resistance, and heart rate. The stretch of connective tissue fibroblasts is capable of affecting the membrane potential of nervous tissue[4]. Both hyperpolarization and inhibitory impulses generated by a stretch of neural and non-neural tissue of the lungs are the likely agents of the autonomic shift during slow deep breathing[4, 5]. Synchronization within the hypothalamus and the brainstem is likely responsible for inducing the parasympathetic response during breathing exercises. The strongest cardiorespiratory coupling which is a parasympathetic phenomenon occurs when there is decreased breathing frequency. Stretch of lung fibroblasts likely contributes to the generation of the slower wave brain activity and the parasympathetic autonomic shift during slow deep breathing exercises[4].

CONCLUSION

Slow deep breathing may be used as a non-pharmaco therapeutic and safe modality, it can be used as an effective lifestyle adjunct to medical treatment to reduce drug dosage and improve quality of life of the patients.

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