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RESEARCH ARTICLE

COMBINED EFFECTS OF *PRANAYAMA* AND *SURYANAMASKAR* ON DYNAMIC SPIROMETRIC VALUES IN NORMAL YOUNG SUBJECTS

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Key Words
Yoga; *Pranayama*; *Suryanamaskar*; Forced Vital Capacity; Peak Expiratory Flow Rate (PEFR)

Background: Good health and freedom from disease is the best achievement of life. Tremendous progress has been made in the field of medicine in recent years. Modern medicine as well as yoga has scientific basis and a universal outlook. It is gratifying that science has started acknowledging the effects of yogic techniques, whereas yoga has started using modern technology and scientific methods. Prana is energy; when the self-energizing force embraces the body with extension, expansion, and control, it is called *pranayama*. *Suryanamaskar* is the combination of asana and *pranayama*. They affect the milieu at the bronchioles and the alveoli particularly at the alveolocapillary membrane to facilitate diffusion and transport of gases. It may also increase oxygenation at tissue level. They have been integrated into physical education in many public and private medical schools across the world. The goal of this study was to identify the effect of *pranayama* and *suryanamaskar* on dynamic spirometric functions.
Aims & Objective: To investigate the effect of *pranayama* and *suryanamaskar* on various dynamic spirometric values (i.e., FVC (L), FEV_1 (L), FEV_3 (L), $FEF_{25-75\%}$ (L), VC (L), FEV_1/FVC (%), and PEFR (L/s) after 6 months of a training program.
Materials and Methods: The duration of the study was 6 months. The participants were divided into four groups namely control, *pranayama*, *suryanamaskar*, and combined group of *pranayama* and *suryanamaskar*. On the first day of the study, the subjects came to a training room and the following tests were conducted. The parameters for lung functions were forced vital capacity (FVC), vital capacity (VC), forced expiratory volume in 1 second (FEV_1), forced expiratory volume in 3 seconds (FEV_3), FEV_1/FVC, and peak expiratory flow rate (PEFR). The exercise regimen for *pranayama* and *suryanamaskar* included the following yogic procedures: *bhastrika pranayama*, *kapalbhati pranayama*, *bhramari pranayama*, *nadi suddi*/*anulom vilom pranayama*, *pranava pranayama*, and *Suryanamaskar*.
Results: The VC, FVC, FEV_1, FEV_3, FEV_1/FVC, PEFR, and $FEF_{25-75\%}$ values were highly significant in the *pranayama* group (group II) than the *suryanamaskar*a group (group III). All the above values were highly significant ($p < 0.05$) in the combined group (group IV) when compared to the other groups.
Conclusion: *Pranayama* and *suryanamaskar*a practice exerts more beneficial effects than physical exercise that mostly affects dimensions of the thoracic cavity. Yoga is a technique of controlling and modulating breath and meditation, a process through which one attains a state of deep rest yet active state of mind. Recent studies on long-term yogic practices have shown improvement in respiratory functions. This aspect of relaxation and detachment has not been mentioned in our education process and it is this new dimension of yoga training that needs to be added to the curriculum. It can make students physically fit and enhance the learning process.

INTRODUCTION

India has a rich tradition of yogic practices. Nowadays yoga, the ancient practice of postures, breathing, and meditation, is gaining a lot of attention from health-care professionals.[1] During practicing of yoga, metabolic activities increase, and therefore both the ventilation and the cardiac systems work harder to meet the increased demand. To do so, an increase in the number of breaths, heart beats per minute, tidal volume, and stroke volume is necessary.[2] Prana is the vital life force or energy that acts as a catalyst in all activities and *ayama* is the expansion or control of this force. *Pranayama*, in which the rhythm of nose breathing and deep abdominal predominance prevails throughout the whole process, is a systematic, controlled exercise of respiration that makes the lungs stronger, improves blood circulation, and makes the individual healthier. This prana is the basic fabric of this universe, both inside and outside our body.[3] The basic translation of *suryanamaskar* is salutations to

the God sun. It is a very ancient Indian tradition, which has been in existence since the Vedic age. The physical basis of the *suryanamaskar* practice links together 12 asanas in a dynamically performed series. These asanas are performed in such a way that they alternately stretch the spine backward and forward. When performed in the usual way, each asana involves alternate inhalation and exhalation. A full round of *suryanamaskar* consists of 2 sets of the 12 poses with a change in the second set to moving the opposite leg first through the series. A study performed on a group of elderly persons indicated that a short-term yoga practice (*suryanamaskar* and *pranayama*) was beneficial and prevented development of primary respiratory problems by increasing the efficacy of respiratory muscles.[4] Joshi et al.[5] studied the significant increase in forced vital capacity (FVC) and peak expiratory flow rate (PEFR) following 6 weeks of *pranayama* practice. Bijlani[6] also reported similar observations. The aim of our study was to find out the effect of combined yoga procedures including *pranayama* and *suryanamaskar* on selected pulmonary function tests (PFTs; dynamic spirometric values) on healthy subjects.

Objectives of the Study: To investigate the effect of *pranayama* and *suryanamaskar* practice on various pulmonary functions (i.e., FVC (L), FEV_1 (L), FEV_3 (L), $FEF_{25–75\%}$ (L), VC (L), FEV_1/FVC (%), and PEFR (L/s) after 6 months of a training program.

MATERIALS AND METHODS

This study was conducted at the Department of Physiology, Meenakshi Medical College Hospital & Research Institute, Kanchipuram, Tamil Nadu, India. After obtaining approval from institutional human ethics committee, 60 medical students aged between 18 and 24 years (20±2 years) of both sexes were selected. Informed written consent was taken from all the participants. The duration of the study was 6 months.

Experimental Protocol

A total of 60 healthy medical students pursuing MBBS were randomly selected and included in our study. The participants were divided into four groups, namely control, *pranayama*, *suryanamaskar*, and combined group of *pranayama* and *suryanamaskar*.

Table 1: Number of groups and participants in the study

Groups	No. of participants	Duration of training
Group I (before yoga group)	20	–
Group II (*pranayama*)	20	6 months
Group III (*suryanamaskar* group)	20	6 months
Group IV (combined group of *pranayama* and *suryanamaskar*)	20	6 months

Selection Criteria

The selected medical students were subjected to the following inclusion and exclusion criteria:

Inclusion Criteria: Volunteers medical students aged between 18 and 24 years, practicing yoga, non-alcoholic, and nonsmokers.

Exclusion Criteria: Previous experience of yoga training, history of major medical illness, for example, tuberculosis, hypertension, diabetes mellitus, bronchial asthma, and major surgery in the recent past.

Training of Yoga Exercise

All the subjects were asked to practice yoga daily for about 1 h. Yoga classes started with a brief prayer. Preparatory practices such as breath–body coordination and joint-loosening exercises were undertaken for 10 min. As mentioned earlier, the duration of the study was 6 months; the yoga was performed for daily 30 min for 5 days a week. This was followed by 30 min of either *pranayama* (group II) or *suryanamaskar* (group III), or a combination of both.

At the end of yoga training exercise, attendance was taken and the subjects were motivated to practice regularly. Some of the classes were preceded by talk on diet and lifestyle modification in controlling chronic lifestyle disorders.

The assessment of parameters for dynamic lung functions (FVC, vital capacity (VC), forced expiratory volume in 1 second (FEV_1), forced expiratory volume in 3 seconds (FEV_3), and FEV_1/FVC, and PEFR) specific to *pranayama*, suryanamaskar and combined yoga training was performed on the students before and after 6 months.

Anthropometric Measurements

Age was calculated in years to the nearest birthday. Height was measured in centimeters while standing using height and weight stand. The reading was

taken nearest to ½ cm. Weight was recorded in kilograms; the reading was taken nearest to ½ kg and the weighing machine was appropriately calibrated from time to time. Body mass index (BMI) was calculated from the formula: BMI = Wt /Ht (m^2).

PRANAYAMA EXERCISE FOR GROUP II SUBJECTS

Pulmonary Function Tests

The PFT was measured by a computerized spirometer (Helios-401; RMS). To measure the flow and volume parameters such as FVC, FEV_1, FEV_3, FEV_1/FV, $FVF_{25–75\%}$, and PEFR, we asked the subjects to take three or four quiet breaths and then instructed to breathe-in fully and then breathe-out as forcefully and completely as possible while standing. This was followed by an equally rapid and complete inspiration. The data obtained were analyzed by Helios-401, and the printouts of values of the above parameters were taken.

The yogic exercises allotted to the group were as follows[7]:

- ***Bhastrika pranayama*:** All volunteers were requested to sit in *padmasana* or *sukhasana*, in such a way that head, neck, and vertebral column would be in a straight line. Then, they were asked to inhale and exhale through both nostrils as fast as they can for 5 min.
- ***Kapalbhati pranayama*:** The subjects were made to sit comfortably with cross-legged position with back straight and hands resting on knees. They were made to inhale deeply through both nostrils expanding the abdomen and exhale with the forceful contraction of abdominal muscles (pull the abdomen in by quickly contracting the abdominal muscles and exhale through the nose). The air was pushed out of lungs primarily by contraction of the diaphragm and secondarily by contraction of all the expiratory muscles. After exhalation and passive inhalation, the lungs were automatically expanded and filled with air. After completing 15 cycles of exhalation and passive inhalation, the students were made to inhale and exhale deeply and were allowed to take rest for about 15–20 s.
- ***Bhramari pranayama*:** In this technique, both the ears are closed with thumb, index finger is on forehead and rest three are on the base of nose touching eyes. The students were asked to breathe-in and -out through nose while humming "OM" like a bee for 10 min.
- **Nadi suddi *Pranayama*/anulom vilom *pranayama*:** The right nostril was closed with the thumb and the participants were asked to take a deep breath from the left nostril. Then, the right nostril was opened with closing of left nostril with middle and ring fingers and they were made to breathe out from right nostril. This was repeated on the opposite nostril.
- ***Pranava Pranayama*:** It was classified into (i) *adhobhagiya*, (ii) *madhyama bhagiya*, and (iii) *urdhwabhagiya.*
- ***Adhobhagiya*:** The subjects inhaled for 10 counts, cautiously making their abdomen to bulge, the breath was stopped for a moment. Then, a slow exhalation for the same duration (i.e., 10 counts) was performed.
- ***Madhyama bhagiya*:** The subjects were made to inhale for 10 counts by cautiously expanding only the chest and asked to slowly exhale for the same duration by continuously contracting only the chest.

SURYANAMASKAR FOR GROUP III SUBJECTS

This practice was started at 4.30 pm with an empty stomach in a clean, ventilated, quiet lab room. *Suryanamaskar* pretraining was given for 7 days by a yoga trainer and the performance of *suryanamaskar* was analyzed using performance chart. The participants were trained to perform *suryanamaskar* in a slow manner so that each of the 12 poses could be held for a duration of 30 s. Each round took 6 min to complete and five rounds were performed in 30–40 min.

Positions involved are as follows:

- **Position 1:** The subjects were made to inhale and maintain it in standing position with hands joined together near chest, feet together, and toes touching each other.
- **Position 2:** The subjects were asked to exhale and bend forward at the waist till their palms touched the ground in line with the toes. They were asked not to bend knees while performing.
- **Position 3:** The subjects were asked to inhale and take the left leg back with left toes on the floor, by pressing the waist downward and raising the neck, stretching the chest forward, and pushing the shoulders backward. The right leg and both the hands were kept in the same position and the right leg was folded.
- **Position 4:** The subjects were asked to hold the

breath and raise the knee of left leg. The right leg was taken backward and kept close to the left leg. Then both the legs and both hands were straightened. They were asked to keep the neck straight and site fixed. Both the toes were erect. Care was taken to see that the neck, spine, thighs, and the feet are in a straight line.

- **Position 5:** The subjects were asked to exhale by bending both the hands in the elbows and touching the forehead on the ground and to touch the knees on the ground by keeping both the elbows close to chest. The forehead, chest, both the palms, both the toes, and knees were made to touch the ground and the rest of the body was not touching the floor. As only eight parts rest on the ground, it is called "*ashtanga*" position.
- **Position 6:** The subjects were asked to inhale and straighten the elbows and to stretch the shoulders upward by pressing the waist downward without bending the arms. The knees and toes were kept on the floor and the neck was bent backward and site upward.
- **Position 7:** The subjects were asked to hold the breath, the neck was bent downward by pressing the chin to the throat. The body was pushed backward and the heel touched the ground. The waist was raised upward, without moving the palms on the floor.
- **Position 8:** The subjects were made to hold the breath as in position 7, the right leg brought to the front and the left leg was placed at the back with left knee and toes on the ground.
- **Position 9:** The subjects were asked to exhale and bring the left leg forward as in the position 2 and place it in between both the arms.
- **Position 10:** The subjects were asked to inhale after getting up and attain position 1.
- **Positions 11 and 12:** They are same as positions 2 and 1. After 6 months of regular practice all the above parameters were reassessed.

STATISTICAL ANALYSIS

All the values obtained before and after performing *pranayama*, *suryanamaskar*, and combined *pranayama* and *suryanamaskar* yogic exercises were expressed as mean±SD. The data were analyzed by SPSS, version 22. 0. One-way analysis of variance followed by Student's *t*-test were used to compare pre- and posttraining results. *p*-Values <0.05 were considered statistically significant.

RESULTS

This study was conducted with the purpose of finding out the outcomes of *pranayama* training, *suryanamaskar* training, and combined training on dynamic spirometric functions in healthy students. All volunteers completed the study.

Anthropometric Measurements

The participants recruited for the pre-yoga training and the study groups were of the same age, weight, height, and BMI group and did not show a statistically significant difference (Table 1). The table shows the age and anthropometric parameters of the subjects. The age of the participant ranged from 18 to 25 years, the mean age of the subjects was 21.47±2.0 years; the mean height was 1.62±0.12 cm; and the mean weight was 58.8 ± 5.01 kg.

Comparison of Spirometric Values during *Pranayama*, *Suryanamaskar*, and Combined *Pranayama* and *Suryanamaskar* Yogic Procedures

The VC, FVC, FEV_1, FEV_3, FEV_1/FVC, and $FEF_{25–75\%}$ values were highly significant in the *pranayama* group (group II) than the *suryanamaskar*a group (group III). But the PEFR value was highly significant (7.26 ±1.48) in the *suryanamaskar* group (group III) than the *pranayama* (group II). All the previously mentioned values were highly significant ($p < 0.05$) in the combined group (group IV) when compared to those of the other three groups. The other respiratory variables such as slow vital capacity (SVC), expiratory reserve volume, inspiratory

Table 2: Comparison of spirometric values during pranayama, suryanamaskar, and combined yogic procedures

Parameters	Before yoga (group I) (n = 20)	After *pranayama* (group II) (n = 20)	After *suryanamaskar* (group III) (n = 20)	Combined group (group IV) (n = 20)
VC (L)	2.66 ± 0.35	3.16 ± 0.76**	2.68 ± 0.42	4.12 ± 0.24
FVC (L)	2.31 ± 0.44	3.1 ± 0.29**	2.68 ± 0.75	4.81 ± 0.1**
FEV_1 (L)	2.72 ± 0.52	3.23 ± 0.76**	2.42 ± 0.25	4.66 ± 1.09**
FEV_3 (L)	5.83 ± 1.82	6.50 ± 1.71**	5.91 ± 0.49	7.43 ± 0.69**
FEV_1/FVC%	81.18 ± 1.43	88.09 ± 1.89**	80.23 ± 0.91*	90.12 ± 2.01**
PEFR (L/s)	6.39 ± 1.08	6.46 ± 1.08	7.26 ± 1.48*	8.02 ± 1.32**
$FEF_{25–75\%}$ (L/s)	4.31 ± 0.77	5.03 ± 0.92*	4.91 ± 1.81*	5.81 ± 1.11*

*Values are expressed as mean ± SD; *p < 0.05 (significant); **p < 0.001 (highly significant)*

reserve volume, and tidal volume (TV) were significantly increased ($p < 0.05$) in the combined (group IV) and *suryanamaskar* (group III) groups. But there was no significant change ($p < 0.05$) in SVC and TV in the *pranayama* group when compared with the control group. All the values were highly significant in the combined group (group IV) than in the other groups (Table 2).

DISCUSSION

The quest for immortality and freedom has always been a fundamental to human civilization. *Hatha yoga* is one of these practices. The Vedas are one of the earliest Hindu literature of hymns consisting mostly of prayers, invocations, and metaphysical speculations of reality. This prototype of yoga included the elements of concentration, austerities, and regulation of the breath as concerned with the recitation of the hymns, surrender of the ego, and the encounter of a reality greater than the ego-personality. There were meditative practices as described by the cosmologic hymns of the Vedas. The earliest form of yoga appears to have been the practice of meditative focusing and sacrificial mysticism.

The participants recruited for the control and study group were almost of the same age, height, weight, and BMI, suggesting that they were well-matched groups (Table 1). Six months of *pranayama* and *suryanamaskar* practice showed significant improvement in vital capacity, FVC, FEV_1/FVC, and PEFR. These findings are in concurrence with those of the studies conducted by Mauch and Day[8] and Upadhyay et al.[9], who showed that there was a significant increase in all lung function values.[Luria et al.[10] conducted a study to find out the effect of dynamic *suryanamaskar* on vital capacity. Dynamic *suryanamaskar* practice proved to be effective in the improvement of vital capacity. Vishwas et al.[11] defined *Suryanamaskar* as, "The salutation to the Sun is also a part of Indian traditional yogic practices." It is used to worship the *surya* (sun) at the time of sunrise (can be done in the evening when the sun sets). Each cycle of *Suryanamaskar* is a sequence of certain "asanas," performed along with "*pranayama*." The sequence of asanas is such that each asana is complimentary to the other. During *Suryanamaskar*, muscles of the entire body experience stretch and pressure alternately, and therefore, it is said to give more benefits with less time. It is claimed that *Suryanamaskar* practice gives benefits of both asana and *pranayama* and improves general health and fitness.

Peck et al.[12] reported that *pranayama* and *suryanamaskar* can be used as a potential equivalent to aerobic exercise with respect to cardiorespiratory endurance. However, its other applications are being explored recently. Improving scholastic performance in schoolchildren has been identified as a major benefit of the combined effects of *pranayama* and *suryanamaskar*, as some earlier reports on physical exercise have shown its beneficial effects in improving the executive functions in children. The results of the present study are in line with those of the earlier report emphasizing physical activity influences attentional tasks. Improvement following the practice of combined exercises can be attributed to physical activity interspersed with regulated breathing and relaxation as the influence of relaxation on attention span is well documented. However, the difference between the groups was statistically significant. The marginal better performance in the combined group can be attributed to the aspect of *pranayama* and *suryanamaskar*, that is, physical activity interspersed with slow breathing and relaxation.

By consistently performing a variety of asana, muscles of the thoracic cavity are constantly being recruited. This recruitment may lead to greater musculature, resulting in improved FVC. Similar observations were made by Upadhyay et al.[9]. The authors concluded that during *pranayama* and *suryanamaskar*, the compliance of the lung thoracic system increases and the airway resistance decreases as a result, hence forceful expiration becomes more efficient. The improvement in FVC could be attributed to increase in development and strengthening of respiratory musculature in regular yoga practitioners.[13] Yogic breathing maneuvers including *suryanamaskar* inflate lung near to total lung capacity, which helps in releasing lung surfactant and prostaglandins into alveolar spaces, increasing lung compliance and decreasing bronchial smooth muscle tone. They help in the removal of infective nasal secretions from respiratory tract, thereby increasing total lung capacities and volumes.[14] In our study, after 6 months of combined yoga practice, there was a significant increase in FEV_1/FVC, FEV_3, and $FEF_{25–75\%}$ values. The probable reason for the observation could be that during *pranayama*, the compliance of the lung thoracic system increases and the airway

resistance decreases, hence forceful expiration becomes more efficient. Also, in *pranayama* and *suryanamaskar* combined exercise, the efficient movement of the diaphragm leads to improvement in FEVs and FVC capacities.[15] 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.[16]

CONCLUSION

Yoga is mind–body technique that involves relaxation, meditation, and a set of physical exercises performed in sync with breathing. Being holistic, it is the best means for achieving physical, mental, social, and spiritual well-being of the practitioners. This can be achieved by systematic and disciplined practice of *pranayama* and *suryanamaskar*. These two limbs of yoga help in our physical development and improvement of physiological functions.

Scientific research has shown that yogic techniques produce consistent and beneficial physiological changes. A few months of disciplined yoga practice can lead to improvement in many physiological and psychological functions. It is claimed that combined practice of *pranayama* and *suryanamaskar* improves general health and fitness. It improves pulmonary and cardiovascular functions. However, *suryanamaskar* is the combination of asana and *Pranayama*, and it is simple to practice and consumes less time so medical professionals can practice it every day. Yoga helps develop many wonderful qualities, and makes the practitioners healthy. It also sharpens the ability to focus, boosts self-confidence, and helps develop self-discipline. We therefore suggest that *pranayama* and *suryanamaskar* should be practiced by everybody, every day to get these benefits.

In the anthropometric parameters of medical volunteers, there was no significant change with regard to weight, height, and BMI of the different groups, proving that they were well matched. It was evident that all pulmonary parameters (i.e., VC, FVC, FEV_1, and PEFR) showed a significant improvement after *pranayama* and *suryanamaskar* yogic exercises.

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