"EFFECT OF SHORT-TERM PRANAYAMA ON PULMANARY PARAMETERS AND BREATH HOLDING TIME"

DISSERTATION SUBMITTED TO

SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH, KOLAR, KARNATAKA.

BY

Dr.SHANKARAPPA.V. M.B.B.S.

IN PARTIAL FULFILLMENT

OF THE REQUIREMENT FOR THE DEGREE OF

DOCTOR OF MEDICINE (M.D)

IN

PHYSIOLOGY

Under the Guidance of

Dr. NACHAL ANNAMALAI. MD

Professor and head of the department of Physiology

DEPARTMENT OF PHYSIOLOGY

SRI DEVARAJ URS MEDICAL COLLEGE

TAMAKA, KOLAR.

APRIL– 2011

DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation entitled ***" EFFECT OF SHORT-TERM PRANAYAMA ON PULUMONARY PARAMETERS AND BREATH HOLDING TIME."*** is a bonafide and genuine research work carried out by me under the guidance of **Dr.NACHAL ANNAMALAI,** MD. Professor and head of the department, Department of physiology, Sri Devaraj Urs Medical College, Kolar.

DATE: SIGNATURE OF THE CANDIDATE

PLACE: KOLAR **DR.SHANKARAPPA.V**

CERTIFICATE BY THE GUIDE

This is to certify that the dissertation entitled **"EFFECTS OF SHORT-TERM PRANAYAMA ON PULMONARY PARAMETERS AND BREATH HOLDING TIME."** is a bonafide research work done by **Dr.SHANKARAPPA.V** in partial fulfillment of the requirement for the degree of **M.D in PHYSIOLOGY**

DATE:

SIGNATURE OF THE GUIDE

PLACE: KOLAR

DR.NACHAL ANNAMALAI, MD
PROFESSOR AND H.O.D
DEPARTMENT OF PHYSIOLOGY

ENDORSEMENT BY THE HOD, PRINCIPAL/HEAD OF THE INSTITUTION

This is to certify that the dissertation entitled **"EFFECTS OF SHORT-TERM PRANAYAMA ON PULMONARY PARAMETERS AND BREATH HOLDING TIME. "** is a bonafide research work done by Dr .SHANKARAPPA.V under the guidance of **Dr. NACHAL ANNAMALAI**, Professor and H.O.D, Department of PHYSIOLOGY.

SEAL & SIGNATURE OF THE HOD	SEAL & SIGNATURE OF THE PRINCIPAL
Dr.NACHAL ANNAMALAI	**Dr. M.B.SANIKOP**
DATE:	DATE:
PLACE: KOLAR	PLACE: KOLAR

COPYRIGHT

DECLARATION BY THE CANDIDATE

I here by declare that the **SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH, DEEMED TO BE UNIVERSITY** ,kolar, karnataka. shall have the rights to preserve, use and disseminate this dissertation / thesis in print or electronic format for academic / research purpose.

DATE:

PLACE: KOLAR

SIGNATURE OF THE CANDIDATE

DR.SHANKARAPPA.V

SRI DEVARAJ URS MEDICAL COLLEGE,TAMAKA, KOLAR,

ETHICAL COMMIITEE

CERTIFICATE

This is to certify that, the Ethical committee of Sri devaraj urs medical college, Tamaka, Kolar. has unanimously approved **Dr.SHANKARAPPA, V** post graduate student in the Department of PHYSIOLOGY OF SRI Devaraj Urs Medical College to take up THE DISSERTATION work entitled **"EFFECTS OF SHORT-TERM PRANAYAMA ON PULMONARY PARAMETERS AND BREATH HOLDING TIME"** to be submitted to the ***sri devaraj urs academy of higher education and research, kolar, karnataka*.**

SIGNATURE OF MEMBER SECRETARY

ACKNOWLEDGEMENT

With an immense sense of gratitude, I thank my guide **Dr. NACHAL ANNAMALAI**, Professor and Head, Dept of physiology Sri Devaraj Urs Medical College, Kolar.for her unsurpassable guidance and encouragement in making this study possible.

I am grateful to **Dr. KARTHIYANEE KUTTY,professor, Dr. VINUTHA SHANKAR.M.S**. Professor, **Dr.SUNANDA NAYAK** Professor, **Dr. ASHWATH KUMAR,**Assistant Professor, **Mrs. USHA SHENOY,** lecturer , Sri Devaraj Urs Medical College, Tamaka, Kolar, for their invaluable support and suggestions throughout the study.

I express my deepest gratitude to my PG's **Dr. Raja Reddy, Dr. Jagadamba, Dr. Kavana G. Venkatappa, Dr. Ashwini K. Shetty, Dr. Soumya P. Kori, Dr. Padmini T, Dr. Sumit Garg, Dr. Ramya C.S. and Dr. Bhanu R.** for their helping hand in the completion of the dissertation and their valuable support during this study. I express sincere heartfelt gratitude to all the subjects for giving their willingness to undergo the required procedure and enabling me to carry out this study. I am also thankful to all the NON TEACHING STAFF in the department for their cooperation and help.

I am also thankful to all non teaching staff members of the department for their support during the study.

I thank **MY FAMILY** for showering their blessings which has helped me throughout & for their constant support and encouragement.

Above all I thank **The Almighty** for his blessings.

LIST OF ABBREVIATIONS

PFT	:	Pulmonary function tests
PYC	:	Patanjali Yoga center
SDUU	:	Sri Devaraj Urs University
HR	:	Heart Rate
BP	:	Blood Pressure
RPP	:	Rate pressure product
DOP	:	Double product
HGS	:	Hand Grip Endurance
FVC	:	Forced vital capacity

FEV_1	:	Forced Expiratory volume after one second
FEV_3	:	Forced Expiratory volume after three seconds
MVV	:	Maximum voluntary ventilation
$FEF_{25-75\%}$	:	Forced Expiratory flow rate 25% - 75%
PEFR	:	Peak Expiratory Flow rate
PIF	:	Peak Inspiratory Flow
TV	:	Tidal Volume
ERV	:	Expiratory Reserve Volume
IRV	:	Inspiratory Reserve Volume
RV	:	Residual volume
BHT	:	Breath Holding Time
NS	:	Not Significant
p	:	Probability Value
S	:	Significant
SD	:	Standard Deviation
Sec	:	Second
VC	:	vital capacity

ABSTRACT

Background and Objectives:

Pranayama when performed regularly has benefits on the various functions of the body. Regular pranayama practice has a favourable influence and cause marked improvement in the lung functions. The study was undertaken to assess the effects of pranayama practice on pulmonary functions in adults in age group of 18 – 35 years.

Method:

50 regular yoga practitioners of both male and female age group between 18-35years young healthy adults from patanjali yoga center, kolar were included in study.

Pulmonary function parameters were measured by Medspiror and Breath holding Time (BHT) by using stop watch. PFT was done before starting of their curriculum and second phase of recording was taken after 6 weeks.

Results:

The study group showed significant increase in pulmonary function test values i.e. FVC, FEV_1, FEV (25-75%), PEFR and also in BHT after 6 weeks.

Interpretation and Conclusion:

PFT values were higher after 6 weeks of pranayama practice in study group. This may be due to regular deep inspiration and expiration during pranayama practice leading to the strengthening of respiratory muscles. The increase in BHT was due to acclimatization of chemoreceptors to the increased concentration of CO_2 gradually by regular practice of pranayama. Therefore a portion of our time should be devoted to regular practice of pranayama.

Key words: Pranava, Savitri and Nadi Shuddi Pranayama; PFT; BHT; Medspiror.

LIST OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

INTRODUCTION

Yoga is a science practiced in India over thousands of years. It is one of the best lifestyle modification ever devised in the history of mankind. There are many classical paths described to reach the ultimate goal of healthy life. Besides spiritual achievements, the practice of yoga is accompanied by a number of beneficial physiological effects in the body.

The Sanskrit word “yoga” comes from the root “yuj” means to join. The most common understanding of the word yoga is “union”. The purpose of yoga is to cultivate a sense of unity – both a “union of the mind with the divine intelligence of the universe” and a sense of union within the individual. Yoga enables a holistic healing of the individual. The philosophy perceives the mind and body as an integrated unity, for which it is considered a mind and body science. “It teaches that, given the right tools and the right environment, the mind and body can find harmony and heal itself. Yoga calms and relaxes the mind, strengthens and tunes the body, and brings them into harmony with one another”. Yoga and health goes hand in hand.

Pranayama is a type of yogic practice, which produces many systemic psychophysical effects in the body besides its specific effects on respiratory functions.

‘Prana’ means breath, respiration, vitality or energy. ‘Ayama’ means expansion or stretching. Thus pranayama connotes extension of breath and its control. Pranayama is an art of controlling the breath .It is conscious unification with the universal vital life force (pran) .Breathing is the most tangible expression of pran and pranayama is the ingenious technique for recharging our energy and enhancing vitality by drawing vital life force from the omnipresent and inexhaustible universal source of prana.[1] It is ancient yoga technique, where it is a spiritual and physical practice integrating mind and body. Pranayama is differing from other forms of exercises and it mainly focuses on sensations in the body. So it has become a standard fare at health clubs & community recreation programmes.

Pranayama can increase or decrease by itself without any external agency. The body may be there without life or prana, but is grossly useless. Thus prana is the basic fabric of this universe both inside and outside our body. A uniform harmonious flow of prana to each and every cell keeps them alive and healthy. Prana has the capacity to move into different areas of the body depending on the demand. [1]

Pulmonary function testing is a valuable tool for evaluating the respiratory system, representing an important adjunct to the patient history, various lung imaging studies. It measures lung volumes and capacities. Pulmonary function tests (PFTs) are simple screening procedure performed using standardized equipment (spirometer) to measure lung function. This test provides useful information about minimum levels of lung function. Breath holding time measures the level of threshold of respiratory center to partial pressure of carbon dioxide (Pco_2) level.

Like drugs, pranayama can be a part of Doctor's Prescription and the prescription is aimed at improving health, reducing disease risk or treating an illness.

Pulmonary function tests have been studied in yoga and pranayama practitioners. It shows that regular practice of these long -term pranayama techniques proved to be beneficial for the human body and it also improves breath holding time. Pranayama when performed regularly has benefits on the various systems of the body.

Regular pranayama practice has a favourable influence and cause marked improvement in the lung functions**.**

This study was designed to study the effects of short- term pranayama (6 weeks) on pulmonary function parameters.

AIMS

AND OBJECTIVES

AIMS AND OBJECTIVES

Aim:

The aim of study is to know the effects of ‘Pranava’, ‘Nadi shuddhi’ and ‘Savitri’ Pranayama practice on pulmonary function tests (FVC, FEV1, FEF $_{25\text{-}75\%}$, and PEFR) and breath holding time in young healthy yoga practitioners.

Objectives:

1) To determine the Pulmonary function tests before pranayama.

2) To determine the Pulmonary function tests after 6 weeks of pranayama practice.

3) To compare the Pulmonary function tests before and after 6 weeks of pranayama practice.

REVIEW OF

LITERATURE

REVIEW OF LITERATURE

HISTORICAL REVIEW:

129-200 AD - Galen did a volumetric experiment on human ventilation.

1681- Borelli tried to measure the volume inspired in one breath. He did this by sucking a liquid up a cylindrical tube.

1718- Jurin J blew air into a bladder and measured tidal volume and maximal expiration volume by Archimedes principle.

1727 - Hales St approves the results of Jurin.

1749 - Bernoulli D describes a method of measuring an expired volume

1788 - Goldwyn E stated that vital capacity could reach as much as 4460ml.

1793 - Abernethy tried to determine depletion of oxygen from expired gases.

1796 - Menzies R determined the tidal volume by body plethysmography.

1799 - Pepys W.H. Jun found the tidal volume to be 270ml by using two mercury

1800 - Davy H measured his own vital capacity and tidal volume by gasometer and residual volume by hydrogen dilution method.

1813 - Kentish E used a simple 'Pulmometer' to study ventilatory volumes in disease.

1831 - Thrackrah C T described a 'Pulmometer' similar to that of Kentish which also measures the power of expiratory muscles.

1844 - Maddock A B published in the Lancet about his 'Pulmometer'. The principle was suggested by late Mr. Abernethy.

1845 - Vierordt described some parameters which are still in use today in modern spirometry like residual volume and vital capacity.

1846 - Hutchinson, John published about his water spirometer. He coined the term vital capacity.

1854-Wintrich developed a modified spirometry.

1859 - Smith E developed a portable spirometer.

1866 - Salter recorded time as well as the volume with the kymograph attached to the spirometer.

1868 - Bert P introduces total body plethysmography.

1879 - Gad J publishes a paper about pneumatograph and suggested a new name as aeropletysmograph.

1902 - Brodie T G used dry bellow edge spirometer.

1904 - Tissot introduces a close-circuit spirometer.

1929 - Knipping H W introduces a standardized method for spiroergometry.

The earliest physiologist established an experimental inquiry into the quantity of air received by a single inspiration.

1933-Assessment of pulmonary function while air is flowing into or out of the lungs began in, the test was known as maximum breathing capacity, the same test now is called maximum voluntary ventilation.

1947 - Tifineau introduced the concept of time vital capacity (FEV_1).

1951- Recording of Timed vital capacity was done.

1955- the measurement of the maximal mid expiratory flow (middle half of FVC i.e. FEF25 – 75%) was done.

1959 - Wright B M and McKerrow C B introduce the peak flow meter.

In the mid 1960s computers were used to display analysis of flow volume and pressure as three dimensional graphs. They applied these techniques to the analysis of forced expiratory maneuver.

1969 - Dubois A B and Yan de Woestijne K P presented the whole body plethysmograph on humans.

1970 -The wide spread application of microprocessors began and gave way to sophisticated pulmonary testing applications. The wide variety of flow-sensing spirometer, metabolic measurement system and pulse oximeter are few of the techniques used for assessing the integrated performance of respiratory system and its individual components.

Important quantitative aspects of respiratory functions are changes in lung volume with inspiration and expiration and the absolute volume of air that the lung can hold at various phases of respiratory cycles. .

For the purpose of quantification and comparison, the total volume of gas in the lungs is conventionally sub-divided into compartments as volumes and combination of two or more volumes as capacities.

The measurement of lung volumes and capacities are made using Spirometer. Spirometers are available in a variety of configurations. Some spirometers primarily sense volume and are known as Volume type Spirometer, while others primarily sense air flow at particular times, which are known as Flow type Spirometers.

In the above type, using manual calculations or employing computers, one can define the relationship between volume, flow and time to get numeric values which give the measure of respiratory system's ability to move air.

Flow type Spirometer use pneumotachograph or rotating turbines to determine air flow. There are two types.

1. Hot wire

2. Flow resistive.

In hot wire type, the air flowing over a heated wire coil will alter its resistance in proportion to changes in airflow. Flow resistive pneumotachograph contains a resistive element composed of parallel tubes, a wire mesh or a fibrous paper like element. Airflow through resistive element results in pressure gradient across the device, which can be measured by a very sensitive differential pressure gauge. The drop in pressure across the resistive element is sensed by a pressure transducer and this pressure is converted to a voltage output that is proportional to flow.

Moreover, the flow signal can be integrated electronically to yield volume. With an electronic spirometer, all the parameters pertaining to lung volumes and flow rates can be measured just by demonstrable maneuvers.

1974 - Campbell et al invented a cheap and light development of a peak flow meter.

1990 - Computerized spirometer was introduced.

PULMONARY FUNCTION TESTS (PFTs):

In the practice of pulmonary medicine, pulmonary function testing have a central role due to the advances in pulmonary physiology and medical instrumentation since 1945.

Pulmonary function test provides an objective and quantifiable measure of lung functions. Pulmonary function tests permit an accurate and reproducible assessment of the functional state of the respiratory system and allow quantification of the severity of disease. These functions depend on the integrity of the airways, pulmonary vascular system alveolar septa, respiratory muscles and respiratory control mechanisms. Tests that could assess the function of the pulmonary system are called pulmonary function test (PFT). [15]

Standardized measurement for assessing the presence and severity of respiratory dysfunction is pulmonary function test. Pulmonary function tests offer the best hope for early detection of COPD and for objective documentation of the severity of occupational lung disease.[16] Assessing pulmonary function range from simple standardized techniques that can be performed rapidly and accurately to detailed methods that are time consuming. Depending on the levels of increasing sophistication pulmonary function assessment can be conveniently divided into three levels.

- FIRST LEVEL INCLUDES:
    a) Measurement of ventilatory functions (Spirometry).
    b) Assessment of gas exchanging ability of the lungs by measurement of arterial blood gas tensions.
- SECOND LEVEL INCLUDES:
    a) Measurement of Static Lung Volumes – FRC, RV, TLC.
    b) Estimation of diffusing capacity of the lungs.
- THIRD LEVEL INCLUDES:
    a) Airway resistance and pulmonary compliance.
    b) Pressure-Volume relationship of the lungs.
    c) Ventilation-perfusion relationship.
    d) Ventilation response to oxygen and carbon dioxide.[16]

For describing the events of pulmonary ventilation, the air in the lungs has been subdivided into four volumes and four capacities as shown in fig .1.

- Lung Volumes

  TV - Tidal Volume

  IRV - Inspiratory Reserve Volume

  ERV - Expiratory Reserve Volume

  RV - Residual Volume

  Pulmonary Capacities

  IC - Inspiratory Capacity

  FRC - Functional Residual Capacity

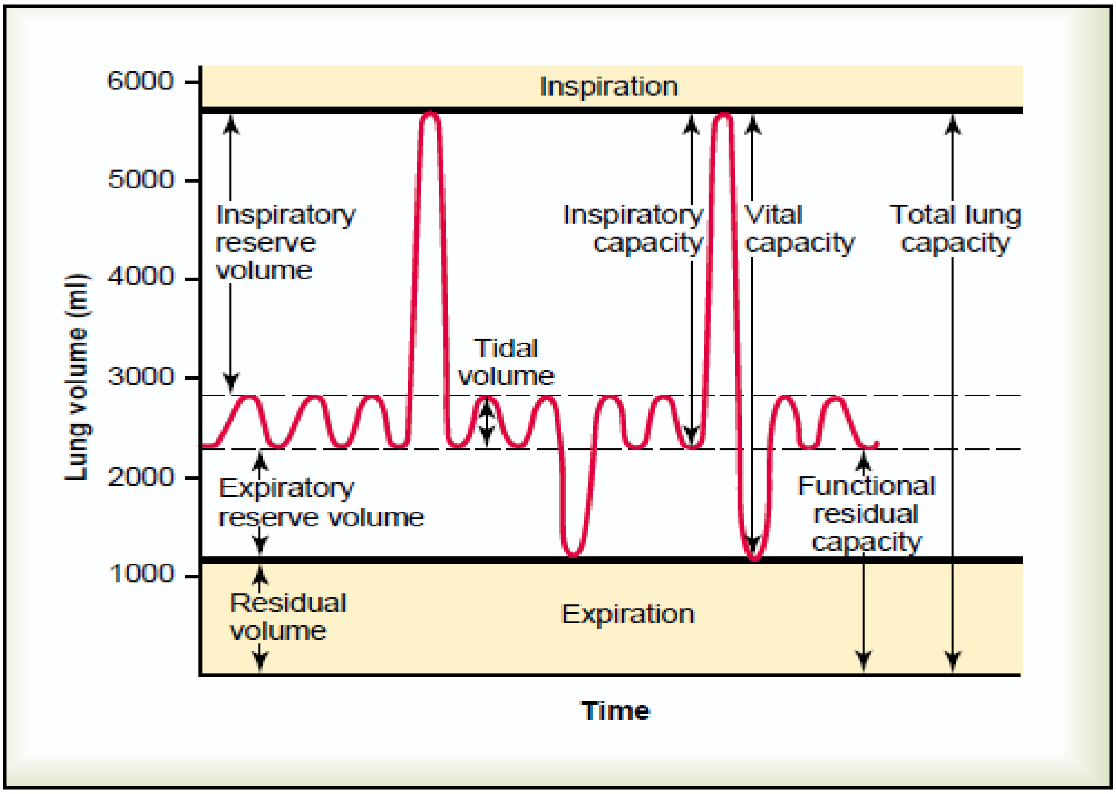
  TLC - Total Lung Capacity

  VC - Vital Capacity

LUNG VOLUMES	NORMAL VALUES (Adults) in ml	
	MALES	FEMALES
1.Tidal Volume: The volume of air inspired or expired with each normal breath.	500	500
2. Inspiratory Reserve Volume: The air inspired with a maximal effort in excess of the tidal volume.	3300	1900
3.Expiratory Reserve Volume: The volume expelled by an active expiratory effort after passive expiration is the expiratory reserve volume.	1000	700
4. Residual Volume : The volume of air in the lungs after a maximal expiratory effort.	1200	1100

LUNG CAPACITIES:	NORMAL VALUES (Adults) in ml	
	MALES	FEMALES
1. Inspiratory Capacity: Maximum volume of air that can be inspired after a normal expiration. TV + IRV	3500	2200
2.Functional Residual Capacity: The amount of air that remains in the lung at the end of normal expiration ERV + RV	2300	1800
3. Total Lung Capacity: The maximum volume to which the lungs can be expanded with the greatest possible effort. VC + RV	5800	4200
4. Vital Capacity: The amount of air that can be expired maximally after a maximal inspiratory effort.[17,18]	4800	3100

Fig .1: SPIROGRAM (LUNG VOLUMES AND CAPACITIES)



Vital capacity is a useful predictor of pulmonary disease and cardiac failure .It is directly related to height and inversely related to the age of individual.[19]

Vital capacity, tidal volume, inspiratory reserve volume, expiratory reserve volume, and inspiratory capacity are measured directly by simple spirometry where as residual volume, functional residual capacity and total lung capacity can be measured by indirect methods using inert gas (like helium) dilution techniques, nitrogen washout technique and Body Plethysmography.[20]

Ventilatory function is measured under static conditions for determination of forced expiratory flow rates. The lung volume measurements should be corrected for body temperature and ambient pressure saturated with water vapour (BTPS).[21]

The cornerstone of all pulmonary function tests is clinical spirometry. Spirometry is measured by different spirometers. The commonest being:

1. Simple spirometer/student spirometer/vitalograph.
2. Recording spirometer.
3. Wright's peak flow meter
4. Computerised spirometer.[22]

SPIROMETRY (DYNAMIC LUNG VOLUMES):

One of the most common pulmonary function tests is spirometry, derived from the Greco-Latin term meaning "to measure breathing". It is the measurement of movement of air in and out of the lungs during various breathing maneuvers. This test, which can be done in a hospital or doctor's office, measures how much and how fast the air is moving in and out of the lungs. Specific measurements taken during the test include the volume of air from start to finish, the flow that is achieved, and the volume of air exhaled in the 1st second of the test.

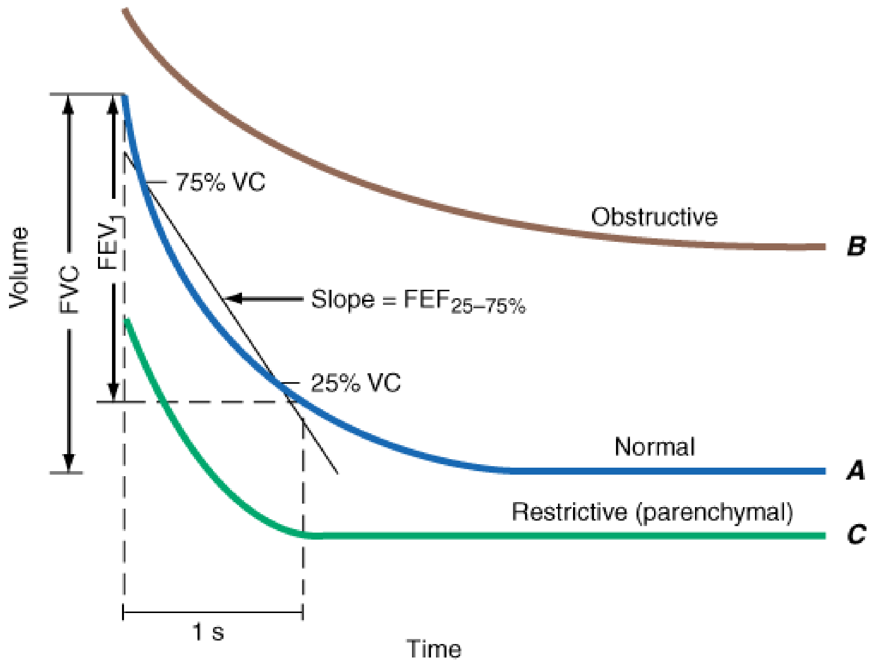


Fig 2. Spirogram [70]

A spirogram is a graphical representation of bulk air movement depicted as a volume-time tracing or as a flow-volume tracing. Values generated from a simple spirogram provide an important graphic and numeric data regarding the mechanical properties of the lungs, including airflow FVC, FEV_1 and others.

The maneuver may be performed in a forceful manner to generate a forced vital capacity (FVC) or in a more relaxed manner to generate a slow vital capacity (SVC). In normal persons, the inspiratory vital capacity, the expiratory SVC, and expiratory FVC are essentially equal. However, in patients with obstructive small airways disease, the expiratory SVC is generally higher than the FVC.

The measurement is typically expressed in liters for volumes or in liters per second for flows and is corrected for BTPS of gas that is saturated with water vapour. Spirogram helps to distinguish obstructive pulmonary disorders such as asthma and emphysema from restrictive disorders such as pulmonary fibrosis and neuromuscular disease.

Spirometry is used clinically to differentiate obstructive versus possible restrictive diseases. A decrease in FEV I/FVC ratio is useful in identifying obstructive lung disease and a decreased FVC with normal or increase FEV1/FVC suggests restrictive lung disease. Visualizing the MEFV curve provides excellent quality control for obtaining reliable measurements of FEV, and FVC. Normal young adults usually complete forced expiration by 3 seconds. Airway function probably reaches a maximum between 18-23yrs but decline thereafter. Middle age healthy non-smokers show an average decline of approximately 30ml/yr.[28]

These tests are often valuable for following the progress of a patient with chronic pulmonary disease and assessing the results of treatment.[29]

The Acceptability and Reproducibility Criteria for Spirograms according to American Thoracic Society standardization guidelines are:

ACCEPTABILITY CRITERIA

Free from artifacts

1. Cough or glottis closure during the first second of exhalation
2. Early termination or cutoff
3. Variable effort
4. Leak
5. Obstructed mouthpiece

Good start

1. Extrapolated volume is <5% of FVC or 0.15 L, whichever is greater or
2. Time to PEF is <120 ms (optional until further information is available)

Satisfactory exhalation

1. 6 sec of exhalation and/or a plateau in the volume-time curve or
2. Reasonable duration or a plateau in the volume-time curve or
3. The subject cannot or should not continue to exhale

REPEATABILITY CRITERIA

After three acceptable spirograms have been obtained, apply the following tests.

1. Are the two largest FVCs within 0.2 L of each other?
2. Are the two largest FEV_1s within 0.2 L of each other?

If both of these criteria are met, the test session may be concluded.

If both of these criteria are not met, continue testing until:

1. Both of the criteria are met with analysis of additional acceptable spirograms or
2. A total of eight tests have been performed or
3. Save a minimum of three best maneuvers [13]

Currently, there are many techniques for assessing both integrated performance of respiratory system and their individual components.

Ventilatory function tests assessed by the rate at which the lung volume changes, during a forced breathing maneuver are:

1. Forced Vital Capacity Maneuver.
2. Maximal Voluntary Ventilation Maneuver.[24]

Technologies used in spirometers

Volumetric Spirometers

- Water bell
- Bellows wedge
- Rolling seal
- Dry

- **Flow measuring Spirometers**
    - Fleisch-pneumotach
    - Lilly (screen) pneumotach
    - Turbine (a rotating vane, the revolutions are counted by light beam)
    - Pitot tube
    - Hot-wire anemometer
    - Ultrasound

Medspiror:

Medspiror is a type of flow sensing Spirometer, which is a low cost high performance instrument capable of giving highly accurate and repeatable test results and represents the major advancement in computerized pulmonary function testing. It is ideal for screening applications where speed, accuracy and repeatability are of utmost importance.

The testing procedures in this instrument are quite simple from the subject's point of view. With full concentration and co-operation of the subject, a series of tests can be carried out within 4-5 minutes. This is designed to be used with an electromechanically pneumotachometer which is attached to the mouthpiece to detect air flow through it. The electronic circuit then converts the raw signal into actual volume and flow rates. This pneumotachometer can even sense a small volume change of 0.1 to 0.2 liter.

Calibration of the Instrument:-

The system is calibrated by using 3 liters Jones syringe. By calibrating with a known volume syringe, the accuracy of the flow sensor and integrator can be checked with one input. A correction factor is calculated based on measured versus expected values.

$$\text{Correction Factor} = \frac{\text{Expected volume of air}}{\text{Measured volume of air}}$$

The accuracy of Spiro meter is tested as follows

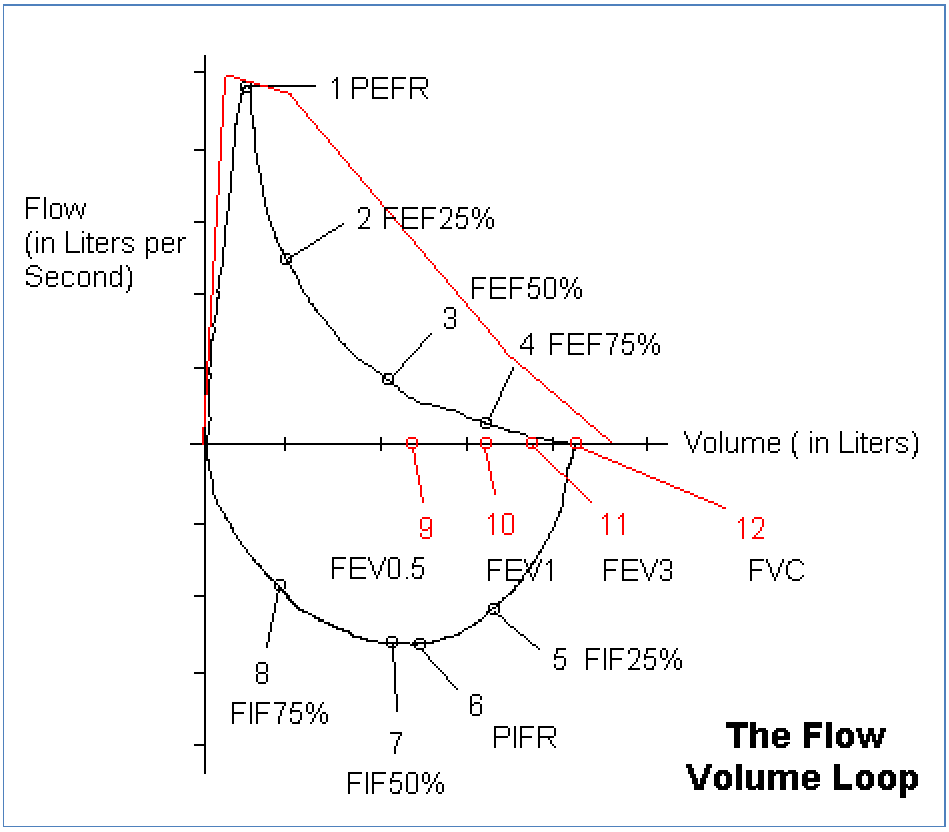
$$\text{Percentage Error} = \frac{(\text{Expected volume - measured volume})}{\text{Expected volume}} \text{ X } 100$$

The maximum acceptable error according to American thoracic society (ATS) recommendations is 3% or exceeds ±50ml, whichever is more. In our study instrument calibration was carried out once in 3 weeks using a 3 liters syringe. [47]

FVC maneuver can be displayed in two different ways

1. Flow – volume loop
2. Spirogram

Fig 3: Flow volume loop:



In Fig. 3: Flow volume loop FVC maneuver can be displayed by recording the instantaneous flow rate versus volume. This is called the flow volume loop. It can record instantaneous flow both during expiration and inspiration. It is recorded by asking the subject to take a maximal inspiration to total lung capacity and then to breath out as fast as possible until he can exhale no further (a maximal exhalation to residual volume), then take a rapid and maximal inspiration.

Flow rates above the horizontal line are expiratory flow volume loop. Flow rates below the horizontal line are inspiratory flow-volume loop. Total lung capacity is the point at which inspiration is maximal. Residual volume is the point at which exhalation is maximal.

The flow-volume loop yields following main pulmonary function tests data:

1. **Forced Expiratory Volume in 1st second (FEV_1)** is the fraction of vital capacity during the 1st second of forceful expiration. Normally 80 -85% of the forced vital capacity is expired in the 1st second (3-4.5 L), 95-97% in 2nd second (FEV_2) and 97-100% in 3rd second (FEV_3). This test detects generalized airway obstruction.[23] FEV_1 is the best test of respiratory function because information on changes with age, gender, ethnic group, growth, and disease is more developed than for any other test, repeatability is good, and it provides useful information across the whole range from normal to advanced disease. FEV_1 is used mainly to assess intrathoracic airway obstruction in clinical practice or in epidemiological surveys. A major application of FEV_1 is the assessment of bronchodilators and bronchoconstrictor responses. Reduction of FEV_1 reflects reduction in TLC (restrictive disease of the lungs). This distinction is assessed by measuring FEV1/FVC. FVC is less repeatable than FEV_1 in airflow obstruction. Therefore for follow up of mild airways obstruction the change in FEV_1 usually provides more reliable information.[24]

2. Forced Vital Capacity (FVC) is the total volume of air that is exhaled during a forced exhalation after maximal inhalation and it is reported in liters (normal 4.5-5 L/sec).

FVC is normally equal to the slow vital capacity. In subjects without airway obstruction the FVC and VC should be within 5% of each other. The FVC and VC differ substantially if the subjects effort is variable or in the presence of severe airway obstruction. Decreased FVC is also a common feature of restrictive lung diseases.

Forced Vital Capacity maneuver measures airflow out of fully inflated lungs. In this maneuver, the subjects inhales maximally to total lung capacity and then exhales as rapidly and completely as possible to residual volume. In full inspiration the lungs are filled by muscular force, to expand the lungs, thorax and stretches the chest to its maximum and the lungs expand passively. After this a full forced expiration rapidly empties the lungs into a device that records flow over time. Normal lungs empty in 6 seconds. Expiratory airflow is a function of muscular effort, elastic recoil of lungs and thorax, small airways and large airways function, and interdependence between small airway and the surrounding alveolar attachments.[25]

It is often referred to as effort independent. This flow rate may also decrease with truly maximum effort, when compared with slightly sub maximal effort. This phenomenon is called negative effort dependence. This measurement is a sensitive indicator of early obstruction in the small distal airways.[26]

3. Peak Expiratory Flow Rate: is the maximum flow rate achieved during the maneuver measured in L/min or L/sec. (Normal – 500L/min). Peak flow is largely a function of the large airway caliber. It greatly depends on expiratory muscle strength and the patient's effort and co-ordination. It is highly effort dependent and hence many clinicians now use PEFR in addition to FVC and FEV1.

4. Forced Expiratory Flow 50% is the volume achieved after exhaling 50% of the total FVC.

5. Forced Expiratory Flow 25-75% (FEF 25-75%) or average mid-maximal expiratory flow (MMEF) is the average flow rate over the middle section of the vital capacity and is calculated from the spirogram by dividing the vital capacity into quarters, drawing a line from the first (25%) and third (75%) quartiles.

This indicates the patency of small airways.

6. **Ratio of FEV_1 to FVC-**

FEV_1 expressed as a percentage of the FVC

FEV_1/FVC >70% - Normal

<70% - Mild obstruction

<60% - Moderate obstruction

<50% - Severe obstruction

Determinants of maximal air flow:

In the flow-volume loop the maximum inspiratory flow is the same or slightly greater than the maximal expiratory flow. Three major factors responsible for the maximum inspiratory flow are:

1) Force generated by the inspiratory muscles decrease as lung volume increases above residual volume.

2) Static recoil pressure of the lung increases as the lung volume increases above residual volume.

3) The airway resistance decreases with increase lung volume as the airway caliber increases.

The first two factors are neutralized and tend to reduce maximum inspiratory flow. Combination of all these three factors causes maximal inspiratory flow to occur about halfway between total lung capacity.

During exhalation, maximal flow occurs early in the manoeuvre and decreases progressively toward the residual volume. Even with increasing effort, maximal flow will decrease as residual volume is approached. As the effort increases, peak expiratory flow increases, but the flow rates at lower lung volumes does not increase indicating with modest effort a maximal expiratory flow is achieved. No amount of effort will increase the flow rates when lung volumes are diminished as shown in Fig. 4. Hence expiratory flow rates at lower lung volumes are said to be effort independent. But events early in the expiratory maneuver are effort dependent that is increasing effort generates increasing flow rates. The first 20% of the flow in the expiratory flow-volume loop is effort dependent.

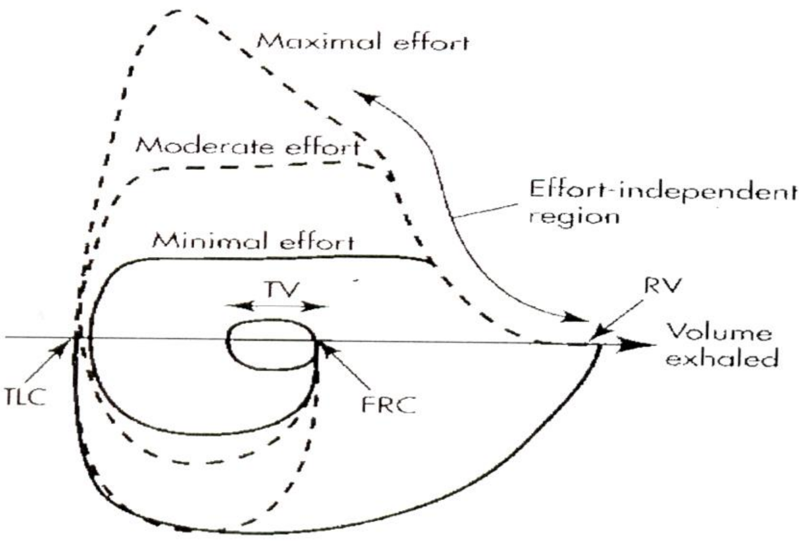


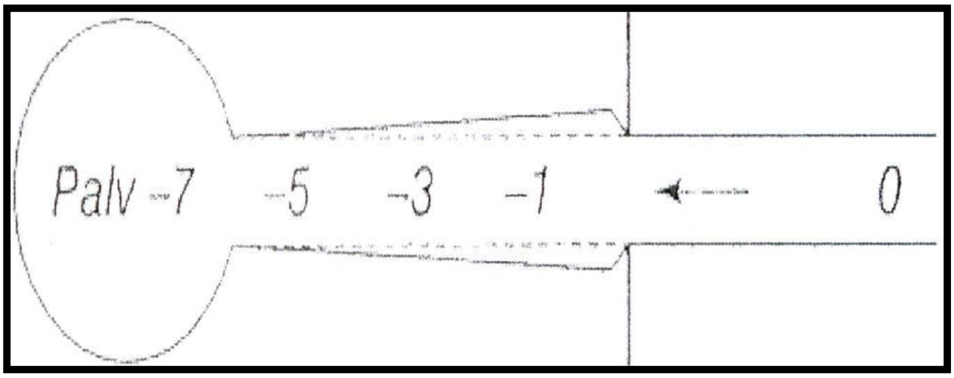
Fig 4: Flow Volume Loop with different efforts

Expiratory flow limitation:

Flow limitation occurs when the airways become compressed. The airways become compressed when the pressure outside the airway exceeds the pressure inside the airway. The expiratory flow limitation occurs as follows:

The collective airways and alveoli are surrounded by the pleural space and the chest wall. At the start of inspiration, before any gas flow occurs, the pressure inside the alveolus (PA) is zero (no airflow), and the pleural pressure is negative (subatmospheric). The transpulmonary pressure (Pd is positive (PL) =PA-Ppd. Because there is no flow, the pressure inside airway is zero and pressure across the airways (Pta transairway pressure) is positive. (Pta=Pairway -PPL). This positive transpulmonary and transairway pressure holds the alveoli and the airways open. When expiration begins, pleural pressure rises from negative towards less negative, alveolar pressure also rises; this is due to increase in pleural pressure and to the elastic recoil pressure of the lung at that lung volume. Alveolar pressure is positive. This is the driving pressure for expiratory gas flow. The alveolar pressure exceeds the atmospheric pressure and gas begins to flow from the alveolus towards the mouth.

As the gas flows out of the alveoli, the transmural pressure across the airways decreases. This is due to the resistive pressure drop caused by the frictional pressure loss associated with flow and decrease in the cross-sectional area of the airways towards the trachea. The gas velocity increases. This acceleration of gas flow further decreases the pressure. As air moves out of the lung, the driving pressure for expiratory gas flow decreases.



PL +7 Ptm +9 +11 +13

Fig 5: Different pressures changes during inspiration

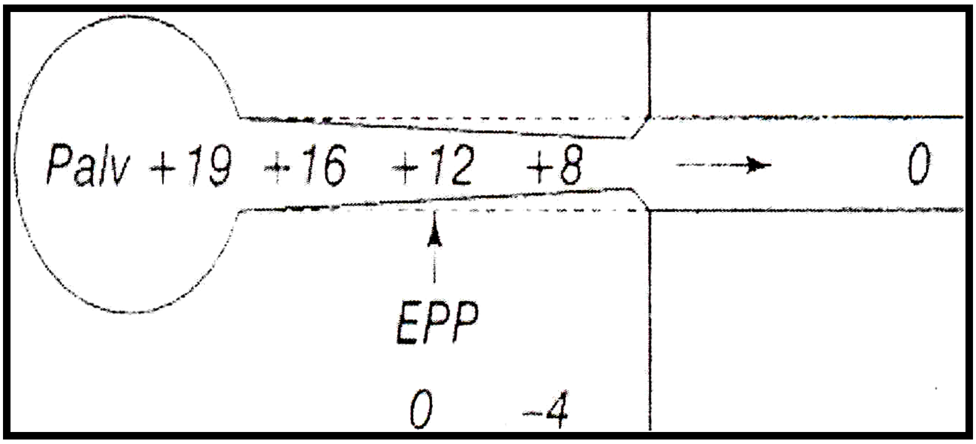


Fig 6. Pressure changes during expiration showing airway compression and equal pressure point.

The point between the alveoli and the mouth at which the intraluminal pressure equals the surrounding pleural pressure is called equal pressure point (EPP) as shown in Fig 6. Airways towards the mouth become compressed, because the pressure outside is greater than the pressure inside (dynamic airway compression). The transairway pressure now becomes negative just beyond the equal pressure point. Increase in effort will not increase the flow further because the higher pleural pressure tends to collapse the airway at the equal pressure point.

Airflow is independent of the total driving pressure. Independent expiratory effort flow is limited. Airway resistance is greater during exhalation than during inspiration. In normal lung equal pressure point occurs in the airways that contain cartilage (segmental bronchi) and thus they resist deformation. Equal pressure point however is not static. As lung volume decreases and elastic recoil pressure decreases the equal pressure point moves closer to the alveoli.[27] Compression occurs in lobar, main stem bronchi and intrathoracic trachea.

Pranayama:

'Prana' means breath, respiration, vitality or energy. 'Ayama' means expansion or stretching. Thus pranayama connotes extension of breath and its control. Pranayama is an art of controlling the breath. Pranayama is the breath control practice to control body energie**s.** It is ancient yoga technique and important step in the practice of Yoga. It is conscious unification with the universal vital life force (pran) .Breathing is the most tangible expression of pran and pranayama is the ingenious technique for recharging our energy and enhancing vitality by drawing vital life force from the omnipresent and inexhaustible universal source of prana.[1]

Tejobindu Upanishad keeps pranayama as step four in fifteen phase schedule of yoga practice. The Asthanga yoga of Pathanjali also considers pranayama as step four in the comprehensive practice of yoga. The Upanishad describing Sadanga yoga places pranayama as step one, two or three in the practice of yoga. [1]

Pranayama has been defined by Patanjal Rishi as dissociation of normal respiratory activities and bring them under volitional control. Pranayama purifies the psychic channels (nadis) and enables physical and mental stability. It has 3 phases namely

1. Pooraka – Inhalation
2. Kumbhaka – holding of breath
3. Rechaka – Exhalation.

Anthara Kumbhaka –breath held after full inhalation but before exhalation

Kumbhaka

Bahya Kumbhaka – breath held after full exhalation but before Inhalation begins.

According to Shankaracharya "Emptying the mind of its illusion is a true Rechaka. The realisation that I am atman (spirit) is a true pooraka and steady sustenance of the mind on this conviction is the true kumbhaka. This is true pranayama".

DIFFERENT TYPES OF PRANAYAMA:

Pranava Pranayama,

Adhobhagiya pranayama practice causes better ventilation in the lower segments of the lungs.

Madhaymabhagiya pranayama practice causes better ventilation in middle portion of lungs.

Urdhwabhagiya pranayama causes better ventilation in upper most portion of lungs.

Therefore the whole lung is ventilated during pranava Pranayama.

Patients with stress disorders, chronic disorders, neck disorders, anxiety disorders and depression benefit from pranava pranayama. [69]

Nadishuddhi Pranayama practice helps to maintain balance between Nadis. The practice causes feeling of freshness, energy and lightness of body and mind.

It promotes balance between the two nostrils apart from cleansing the nasal tract. It increases the vitality. It is beneficial in respiratory disorders such as bronchial asthma, nasal allergy, bronchitis, etc.

Savitri pranayama is an effective way to develop respiratory musculature[29] Nayar et al also have reported a highly significant increase in BHT after yoga training. They have suggested that, Pranayama can be used for short periods of conscious control of rate and depth of breathing.[18]

PHYSIOLOGY OF PRANAYAMA:

Pranayama is an art of controlling the breath. Pranayama is a type of yogic breathing exercise. It is a form of physiological stimulus requiring the response of many functions within the body. As a general rule repeated stimulation of a functional system produces an adaptation to an enhanced recovery from that stimulus. Thus breathing exercise is a form a physiological stimulation, and practice is a form of adaptation to the repeated stimulus.[9]

Breathing is the only autonomic function that can be consciously controlled and it is the key to bring the sympathetic and parasympathetic nervous system into harmony.

There occurs strengthening of respiratory musculature incidental to regular practice of pranayama breathing, during which the lungs and chest inflate and deflate to fullest possible extent and muscles are made to work to maximal extent.[40]

During pranayama training, regular inspiration and expiration for prolonged period leads the lungs to inflate and deflate maximally. Yogic breathing causes strengthening of respiratory muscles and enhances the endurance of respiratory muscles.[4]

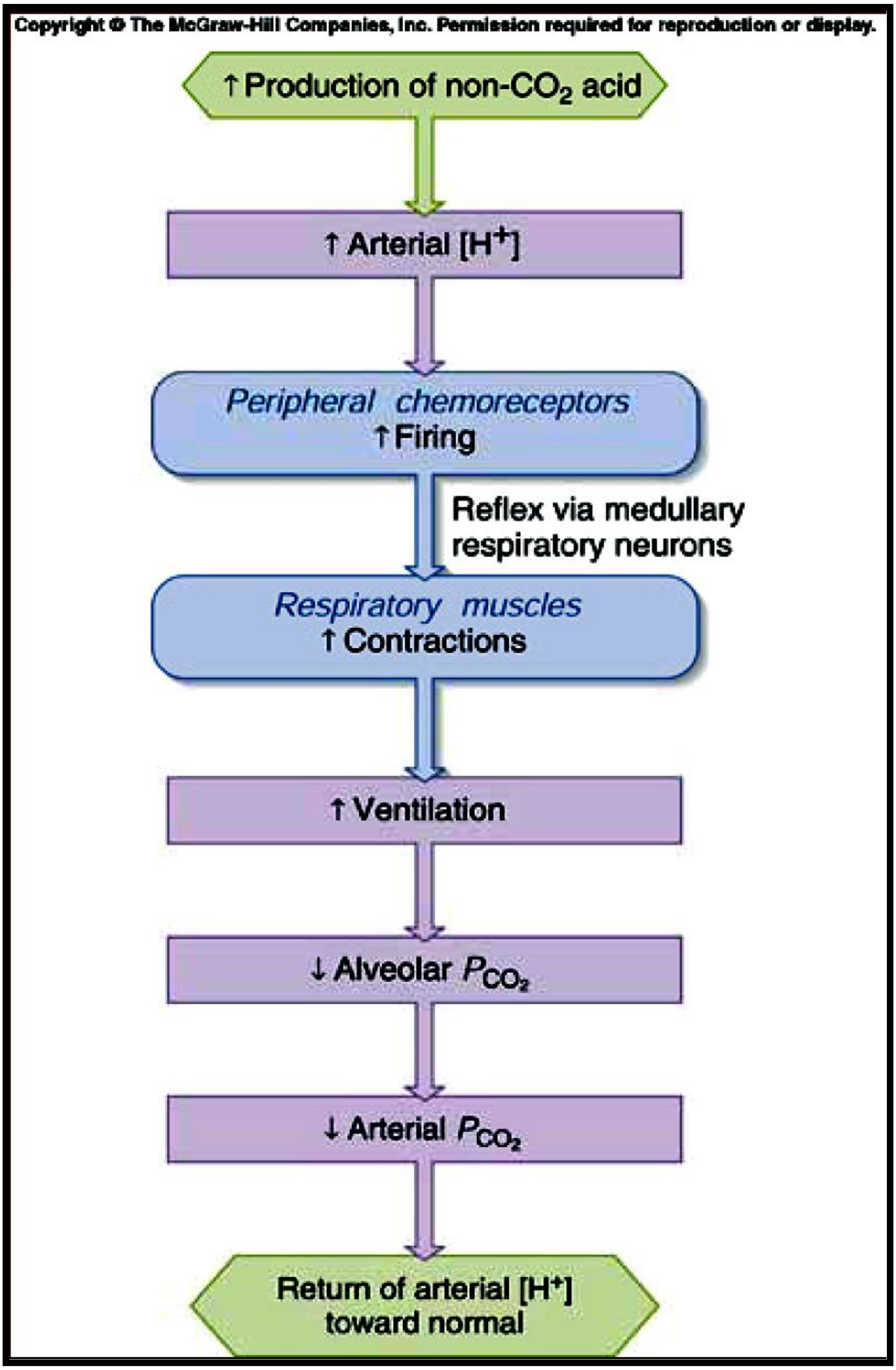
In pranayama breathing, all the alveoli of both the lungs open out evenly. Due to the even expansions of all the alveoli a vast expanse of alveolar membrane is available for exchange of gases. This maximum inflation and deflation is an important physiological stimulus for the release of surfactant[52] and prostaglandins into the alveolar spaces[53]. This increases lung compliance.

In pranayama the individual prolongs the phase of inhalation voluntarily, so that, lungs are expanded considerably and the walls of the alveoli are stretched to the maximum. Stretching of lung tissue produces inhibitory signals by action of slowly adapting stretch receptors (SARs) and hyperpolarisation current by action of fibroblasts. Stretch receptors reflexly decreases tracheo- bronchial smooth muscle tone activity which leads to decreased air flow resistance and increases airway caliber. This improves dynamic parameters of lung function test. Both inhibitory impulses and hyperpolarisation current enhance synchronisation between lung and cortex.[66]

In pranayama the individual prolongs the phase of inhalation voluntarily, so that, lungs are expanded considerably and the walls of the alveoli are stretched to the maximum. Thus the chest continues to get expanded under cortical control. The stretch receptors are thus trained to withstand more stretching. This helps them to hold the breath for a long period. The duration of Kumbhaka is gradually increased by the practice of Pranayama so that the respiratory centre is gradually acclimatized to withstand a high PCO_2 concentration in the arterial blood.

The chemoreceptors, located in the Medulla Oblongata near the entry of the 9^{th} and 10^{th} Cranial nerve, are sensitive to the concentration of PCO_2 in the blood. The CO_2 stimulates these Chemoreceptors which in turn send impulses to the respiratory centre. The Respiratory Centre should start exhalation but in pranayama, strong voluntary control from the cortex prevents it to do so. In this way, the individual practicing Pranayama is training the Chemoreceptors to tolerate high PCO_2 tension.

During Khumbhak the peripheral Chemoreceptors which are sensitive to decrease PO2 level in the blood would also send powerful stimulation to the respiratory center to start the expiration. As the CO_2 goes on accumulating in Khumbhak, the chemoreceptors report it promptly to the pneumataxic centre which in turn tries to stimulate expiratory centre. The autonomic or the reflex mechanism of respiration is far more powerful than the control from the higher centers. That is why after a particular stage it is not possible to hold the breath further. The receptors however get acclimatized to the increased PCO2 gradually by regular practice of pranayama.[62]



Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.
↑ Production of non-CO_2 acid
↑ Arterial $[H^+]$
Peripheral chemoreceptors
↑ Firing
Reflex via medullary respiratory neurons
Respiratory muscles
↑ Contractions
↑ Ventilation
↓ Alveolar P_{CO_2}
↓ Arterial P_{CO_2}
Return of arterial $[H^+]$ toward normal

Fig7. Chemical regulation of respiration.

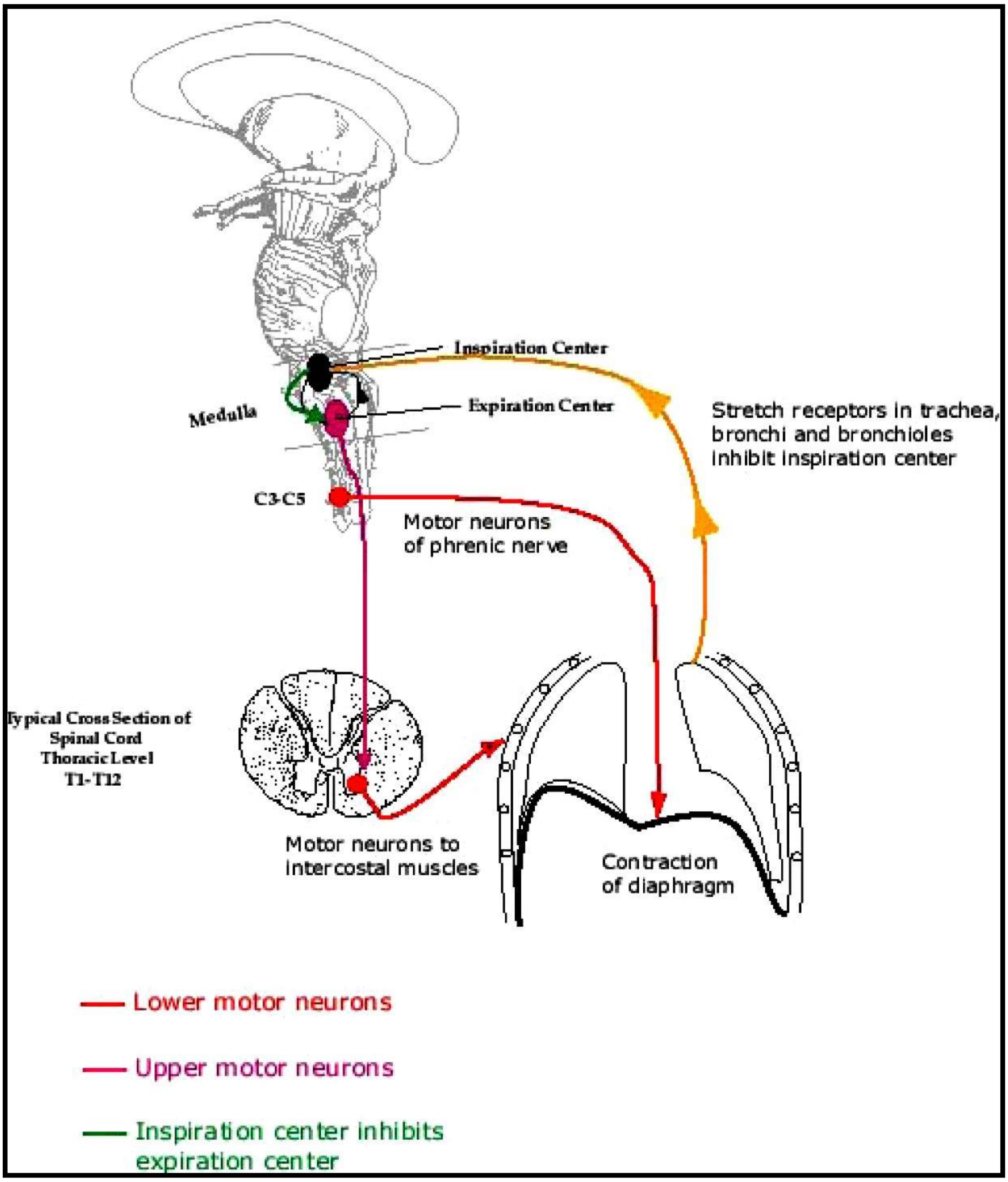


Fig 8: Neural regulation of Pranayama

Yoga practice showed a statistically significant reduction of anxiety on the day of exam in students. These points to the beneficial role in causing reduction in basal anxiety score in stressful state.[2]

Twenty-two healthy school boys in the age group of 13-16 years who had received training in yoga for 3 months and were able to perform Mukh Bhastrika, were considered as the study group. In these subjects, a decrease in reaction time indicates an improved sensory – motor performance and enhanced processing ability of Central nervous System (CNS). This may be due to greater arousal, faster rate of information processing, improved concentration and an ability to ignore extraneous stimuli.[3]

Yoga training modulates the cardiovascular response to exercise and in time course after exercise. It is concluded that after yoga and pranayama training a given level of exercise leads to a milder cardiovascular response, suggesting better exercise tolerance. [4]

Training is usually defined as a systematic process of repetitive, progressive exercise or work and also involves the learning process and acclimatization.

One study has reported that pranayama training results in significant increase in the Hand Grip Strength (HGS) [5] and Hand Grip Endurance (HGE) of both hands and also significant increase in maximal work output with a significant reduced level of oxygen consumption per unit work.[6]

On the other hand, another study concluded that yoga training produces an increase in motor speed for repetitive finger movements.[7]

Yet another study showed that eight weeks of yoga training resulted in a significant increase in isokinetic muscular strength and isometric muscular endurance.[8]

Studies also showed that yoga practice resulted in a significant improvement in the chronic psychoneurotic patients.[9]

Breathing is the only autonomic function that can be consciously controlled and it is the key to bring the sympathetic and parasympathetic nervous system into harmony. Breath is the only function through which we influence the involuntary nervous system, i.e. we can establish rhythms of breathing with our voluntary nerves and muscles that will affect the involuntary nervous system.

Some of the studies found respiratory response with adrenocortical hyperactivity in pranayama practitioners.[10]

A study conducted in persons practicing the right nostril pranayama, oxygen consumption showed significant increase of 37% and 24% increase in oxygen consumption in left nostril pranayama practice. In alternate nostril pranayama practitioners there was 18% increase in baseline oxygen consumption. These results suggest that selectively through either nostril could have a marked activating effect or a relaxing effect on the sympathetic nervous system.[11]

Endocrine and metabolic assessment of the subjects practicing yoga shows enhanced adrenocortical activity, reduction in serum cholesterol, reduction in fasting blood sugar and restoration of serum protein levels. [12]

A study conducted on 10 males and 10 females aged 17-22 years did not show any significant change in GSR after Pranayama but PEFR showed a significant increase in females after 8 weeks after left nostril breathing. [14]

Systemic work increments improve voluntary responses of the organs. Through consistent repetition, the conscious movements become more automatic and more reflexive in character, requiring less concentration by the higher neural centres and then reduce the amount of energy expanded, through the elimination of movements unnecessary for performing of the desired task. Due to systemic training a number of physiological adaptations takes place which lead to a greater energy potential within each muscle cell.

EFFECT OF PRANAYAMA PRACTICE ON PULMONARY FUNCTION TESTS:

Practice of pranayama is so simple and harmless that even children, sick and the aged can also practice it without any harm. Rate of breathing changes with circumstances. Due to emotional disturbances or anger, the rate of breathing increases whereas if one is calm, the rate of breathing automatically slows down.

Pranayama is the science of breath. Proper rhythmic pattern of slow deep breathing strengthens the respiratory system, soothens the nervous system and reduces craving. The mind is set free and becomes fit for concentration. The life span of an individual depends on his mode of respiration. Ancient yogis who resided in seclusion of the forest noticed that animals with slow breathing rate such as snakes, elephants and tortoises had a long life span.

Animals with fast breathing rate like birds, dogs, rabbits etc had short life span. This observation enabled them to realize the importance of slow breathing.

Studies have shown that both normal and forced vital capacities were increased after practicing pranayama and yogasana.[3] Nadi shodhana pranayama significantly improves the forced vital capacity of individuals.

In a study, two groups of male volunteer's 20-35years in age, having same average height and weight were studied. The test group consisted of 14 subjects trained in yogasanas and pranayama for a period of 6 months. The control group consisted of 14 normal untrained subjects, who carried out non-yogic exercises i.e., long walks and playing light games regularly. Tidal volume, vital capacity, maximum breathing capacity, maximum expiratory pressure, FEV was recorded before and after training. There was significant increase in TV, VC and a significant decrease in RR in test Group.[30]

In another study, the effect of pranayama and yogasana practice on normal healthy volunteers (73 males and 27 females) was done for 90 days. FEV_1, FVC, PEFR, FEV_1/FVC%, $FEF_{25-75\%}$, MVV were noted at 3 different periods of the study. FEV1, FVC, $FEF_{25-75\%}$ and MVV were increased significantly in both males and females.[31]

A study was conducted on 53 cadets of National Defense Academy (NDA). The study group was further divided into 3 groups. The group which practiced yoga along with normal NDA training recorded an significant increase in FEV_1 and BHT when compared with groups doing normal NDA training and group doing normal NDA training plus Athletics.[33]

There was significant increase in FVC, MVV and PEFR and decrease in respiratory rate both in males and females after 6 weeks of training of pranayama.[34]

Twenty five normal male volunteers undergoing 10 weeks of pranayama practice have shown improved ventilatory functions in the form of lowered respiratory rate, increased forced vital capacity, FEV_1, maximum breathing capacity and BHT.[35]

In a study on 60 healthy female subjects aged 17-28 years after 12 weeks of yoga and pranayama practice there was significant increase in FVC, FEV1 and PEFR.[36]

Yogic asanas and pranayama have been shown to reduce the resting respiratory rate. Further they increase the vital capacity, timed vital capacity, maximum voluntary ventilation, breath holding time and maximal inspiratory and expiratory pressures. [37]

Effect of Pranayama on asthmatics

Effect of pranayama was studied in 20 males and 10 females suffering from perennial asthma, who were undergoing yoga training at Vemana yoga research institute, Secunderabad. They practiced pranayama for 75 days. The results indicated increment in FEV_1, FVC and PEFR but FEV_1/FVC % remained unchanged.[38]

Fifty three patients with asthma who underwent training for 2weeks showed significantly greater improvement in peak flow rate.[39]

After an initial integrated yoga training program of 2 to 4 weeks, 570 bronchial asthmatics were followed up for 3 to 54 months. Peak expiratory flow rate values showed significant improvement of patients toward normalcy after yoga.[40]

Effect of yoga and pranayama were assessed in 41 patients of bronchial asthma over 6-8 weeks. There was improvement in FVC, FEV_1 and PEFR and $FEF_{25-75\%}$.[41]

Immediate effects of pranayama on ventilatory functions in patients with moderate airway obstruction were studied and compared with the response to that of salbutamol aerosol. Though significant increase in $FEV_1/FVC\%$ was seen after pranayama in patients, the degree of change was not comparable to that of salbutamol aerosol.[42]

EFFECT OF PRANAYAMA ON BREATH HOLDING TIME:

The term 'break point' is defined as the voluntary termination of breath holding in response to the development of net ventilatory stimulus too strong to be further resisted by voluntary effort. During breath holding the Partial Pressure of Oxygen (PaO_2) falls and PaCo2 rises providing reasons for the breaking point.

A study was done on 12 apparently healthy normal young male volunteers who practiced yoga for 6 months. BHT showed increase with high statistical significance.[26]

In a study on 10 healthy male adults, BHT was determined before and after practicing pranayama. They were put through daily practice of Nadishodhana pranayama for 30 days. Then after 30 days it was seen that BHT was significantly increased.[43]

Studies have shown practice of pranayama has lead to increase in breath holding time in young normal persons. [34, 35, 44, 35]

In a study training conducted for 7 days in a camp in Adhyatma Sadhana Kendre, New Delhi, showed significant improvement in BHT.[46]

METHODOLOGY

MATERIALS AND METHODS

Methods:

The study group consisted of 50 young adults (26 male and 24 female) who were newly recruited for yoga training at patanjali yoga center and SDUMC, Kolar, Informed consent was taken from all the subjects who volunteered for the study. They were motivated to undergo pranava, Nadishuddi and Savitri Pranayama training for 1 hour daily for 6 days a week. The first phase of recording of pulmonary parameters was done at the beginning of their course. The second phase of recording was done after 6 weeks of regular pranayama practice.

INCLUSION CRITERIA:

Young healthy subjects aged between 18-35 years.

EXCLUSION CRITERIA:

The subjects with history of

1) Allergic disorders or respiratory disorders.

2) Smoking.

3) Systemic disease like Diabetes, Hypertension, Collagen disorders.

4) Treatment with beta-agonists or xanthenes group of drugs.

5) Chest deformities like kyposis, scoliosis.

Systemic disease and respiratory disorder were ruled out by history and clinical examination.

Anthropometric measurement were recorded

- Age was calculated in years to the nearest birthday.
- Height was measured in centimeters while standing. Reading was taken nearest to ½ cm.
- Weight was recorded in kilograms, reading was taken nearest to ½ kg and weighing machine was appropriately calibrated from time to time.

Pulmonary Function Tests were determined by using Medspiror model (computerised spirometry) and Breath Holding Time was measured using stop clock.

The curriculum of the study group is as follows:

The practice of pranayama was for 1 hour a day in the morning (6.30 am to 7.30 am) for six days per week. All of them were compulsorily asked to have balanced vegetarian diet.

Pulmonary function tests:-

Pulmonary functions were tested using the instrument 'Medspiror' (a self calibrating computerized spirometer that fulfills the criteria for standardized lung function tests) available in the department of physiology, SDUMC. Pulmonary functions were tested at the start of the course and after 6 weeks.

The parameters studied were,

- Forced vital capacity (FVC)
- Forced expiratory volumes (FEV_1)
- Peak expiratory flow rate (PEFR)
- Forced expiratory flow 25-75 % (FEF 25-75%)

Procedure:

The subjects were familiarized with the set up and detailed instructions and demonstrations were given to our satisfaction. The subjects were made to breathe out forcefully following deep inspiration into the mouthpiece attached to the pneumatachometer. Expiration was maintained for a minimum period of 3-4 seconds. 3 to 4 trials of maximal inspiratory and expiratory efforts were made and only the highest reading was taken for data processing.

As recommended by Snowbind workshop all the readings were taken in standing position.[68] All the tests were carried out at the same time of the day, between 8.30 am to 9.30am to avoid possible variations because rhythmic changes in physiological functions have been found to be associated with changes in performance during this period.[51]

The tests were done in a quiet room in order to alleviate the emotional and psychological stresses. During the tests, maximum effort from the subjects was ensured by adequately motivating them to perform at their optimum level. A normal PEFR value of 3-5 L/sec ensured maximum effort by the subject while performing the test.

Nose clips were not used since there was no significant difference in FVC with the use of nose clips.[47]

BREATH HOLDING TIME RECORDING:

Procedure: In sitting posture the subject was asked to hold breath. Breath was maintained until the subject can no longer hold the breath voluntarily and time is noted using a stop watch. This records the BHT.

The detail of the pranayama practicing schedule is as follows:

They performed initial stretching exercises for 10 mins before starting pranayama. The subjects sat in Padmasana. The left arm was straight and was placed on left knee. All the three types of Pranayama i.e. Pranava, Nadi shuddi and Savithri Pranayama were done one after the other. Each one was done for 10 rounds.

Pranava Pranayama is classified into:

- Adhobhagiya
- Madhyama bhagiya
- Urdhwabhagiya

Adhobhagiya: The subjects inhaled for 10 counts making their abdomen to bulge, cautiously, the breath was stopped for a moment. Then slow exhalation for same duration (i.e. 10 counts) by drawing abdomen inwards was done.

Madhyama bhagiya: The subjects inhaled for 10 counts by cautiously expanding only the chest, and slowly exhaled for same duration by continuously contracting only the chest.

Urdhwabhagiya: Raising the collar bones and contracting the abdomen muscles the subjects inhaled slowly for a period of 10 counts, and exhaled slowly for 10 counts.

This procedure was done for 10 rounds.

Nadisuddhi pranayama : The subjects sat in Padmasana. Right nostril was closed with the right thumb and complete exhalation was done through left nostril. Then inhalation was done through the same nostril.

Left nostril was closed with ring finger; right thumb was released to exhale slowly and completely through the right nostril.

Then the subjects inhaled deeply through right nostril. Now the right nostril was closed and the subjects exhaled through left nostril.

This completed one cycle of Nadishuddi Pranayama. They repeated the same for 10 rounds. [69]

Savitri Pranayama :

By sitting in Padmasana, the subjects breathed in through both nostrils for 6 counts and held the breath in for 3 counts. Then the subjects breathed out through both nostrils for 6 counts then held the breath for 3 counts. They repeated the same for 10 rounds.[63]

Fig. 9: PFT Procedure – Performance by Subject

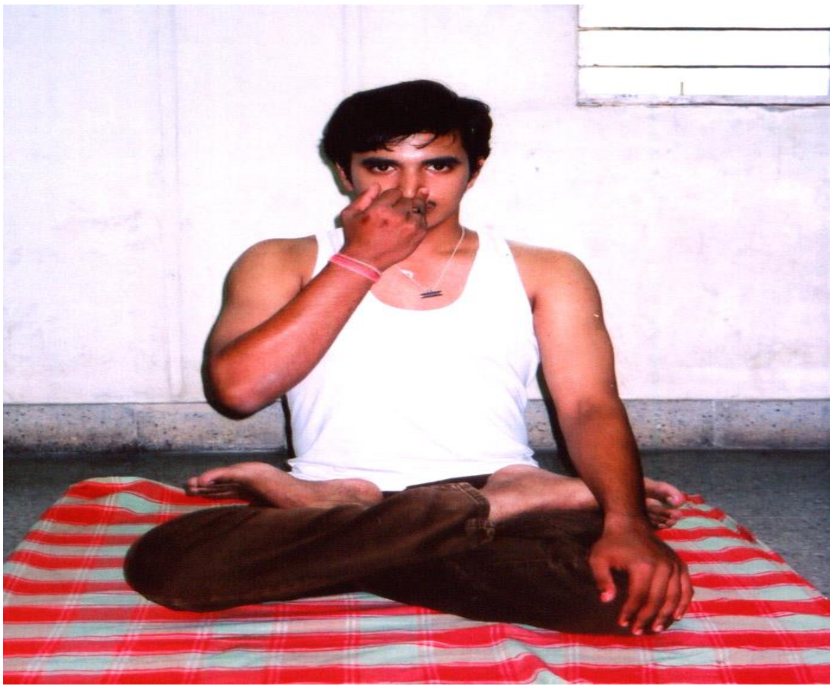


Fig 10: Pranayama Procedure – Performance by Subject

STATISTICAL ANALYSIS

An evaluation of non-controlled study with 50 adult subjects was undertaken to study the effect of 6 week pranayama on lung parameters. The study group's mean age Mean ± SD: 25.76±5.51years.

Descriptive statistical analysis has been carried out in the present study. Results on continuous measurements are presented on Mean ± SD (Min-Max) and results of categorical measurements are presented in Number (%). Significance is assessed at 5 % level of significance. Following statistical methods were employed in the present study.

- ANOVA – repeated measure
- Independent samples 't' test
- Paired samples 't' test

1. ANOVA-Repeated Measures (Analysis of Variance):

The Repeated measures procedure provides analysis of variance when the same measurement is made several times on each subject.

2. Independent sample 'T' test:

Compares 'means' for two independent groups.

3.Paired sample 'T' test : The paired sample 'T' test procedure compares the 'mean' of two variables for a single group.

4. Difference of effect Size (delta)

$$d = \frac{mean1 - Mean2}{PooledSD}$$

No effect (N)	**d<0.20**
Small effect (S)	**d>0.20- <0.50**
Moderate effect (M)	**d>0.50 - <0.80**
Large effect (L)	**d>0.80- <1.20**
Very large effect (VL)	**d>1.20**

5. Significant figures

+ Suggestive significance p value :$\leq$ 0.05

** Strongly significant (p value: $p \leq 0.01$)

Statistical software: The Statistical software namely SPSS 15.0 were used for the analysis of the data and Microsoft word and Excel have been used to generate graphs, tables etc. [55,56,57,58.]

RESULTS

AND

ANALYSIS

RESULTS AND ANALYSIS

The study was undertaken to assess the effect of Pranava, Nadi shuddi and Savitri Pranayama practice on pulmonary function tests and breath holding time.

The study group consisted of 50 volunteers (26 males and 24 females) of Patanjali yoga center and SDUMC, Kolar.

The first phase of recordings in study group was taken at the beginning of their course. i.e., before starting of Pranayama practice and second phase of recordings after 6 weeks regular practice of Pranayama.

Results were tabulated and analysed statistically by using student T test and ANOVA.

Parameters included in study are:

FVC is expressed in liters / min

FEV_1 expressed in liters / min

FEF 25-75% expressed in liters / min

PEFR is expressed in liters / second

BHT is expressed in seconds.

Table 1: Comparison of males and females in study group.

Gender	**Number of subjects**	**%**
Male	26	52.0
Female	24	48.0
Total	50	100.0

Table 1 shows 52 % were males & 48% were females.

Fig. 11 : Percentage comparison of study group (gender)

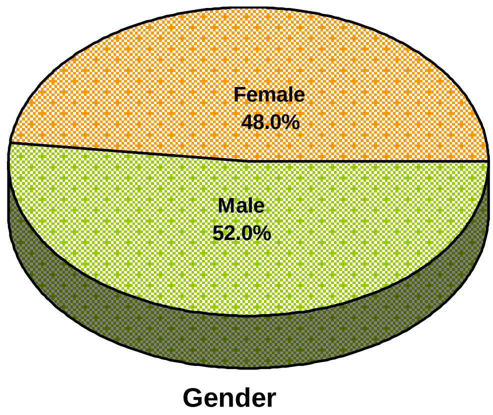


Table 2: Comparison of effect of 6 weeks PRANAYAMA on lung parameters.

Variables	**Before**	**After**		**P value**	**Effect size**
FVC (L/min)	2.60±0.40	3.20±0.43		<0.001**	1.43
FEV1 (L/min)	2.36±0.36	2.96±0.42		<0.001**	1.54
PEFR(L/sec)	6.09±1.03	7.38±1.12		<0.001**	1.19
FEF (25-75%)(L/min)	2.93±0.47	3.74±0.45		<0.001**	1.75
BHT(sec)	38.34±4.34	56.62±9.01		<0.001**	2.74

FVC - before pranayama showed 2.60±0.40 & after pranayama showed 3.20±0.43 which is statistically significant (P<0.001) compared to before pranayama.

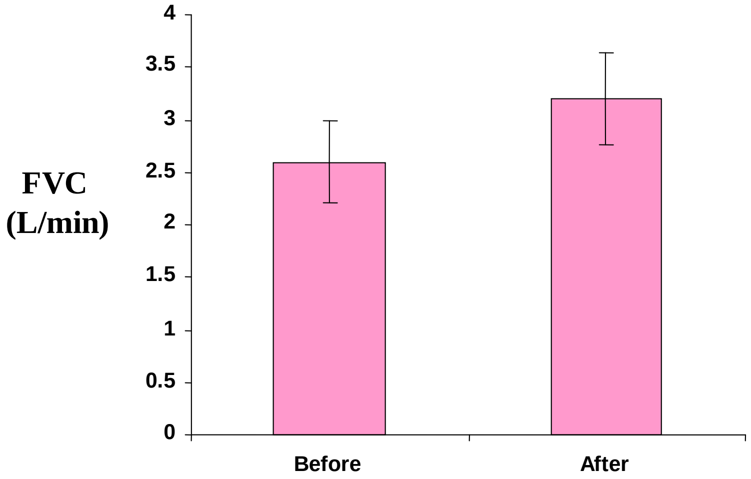
FEV1- before pranayama showed 2.36±0.36 & after pranayama showed 2.96±0.42 which is statistically significant (P<0.001) compared to before pranayama.

PEFR- before pranayama showed 6.09±1.03 & after pranayama showed 7.38±1.12 which is statistically significant (P<0.001) compared to before pranayama.

FEF (25%-75%) - before pranayama showed 2.93±0.47 & after pranayama showed 3.74±0.45 which is statistically significant (P<0.001) compared to before pranayama.

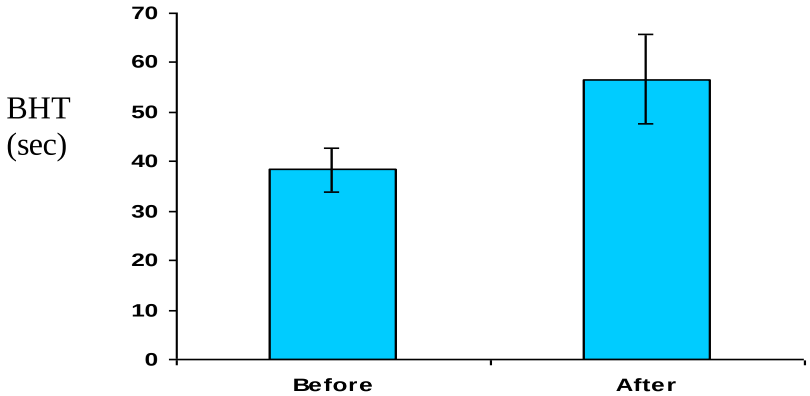
BHT - before pranayama shows 38.34±4.34 & after pranayama showed 56.62±9.01 which is statistically significant (P<0.001) compared to before pranayama.

Fig. 12: Comparison of lung parameter FEV (L/min) before and after 6 weeks of pranayama



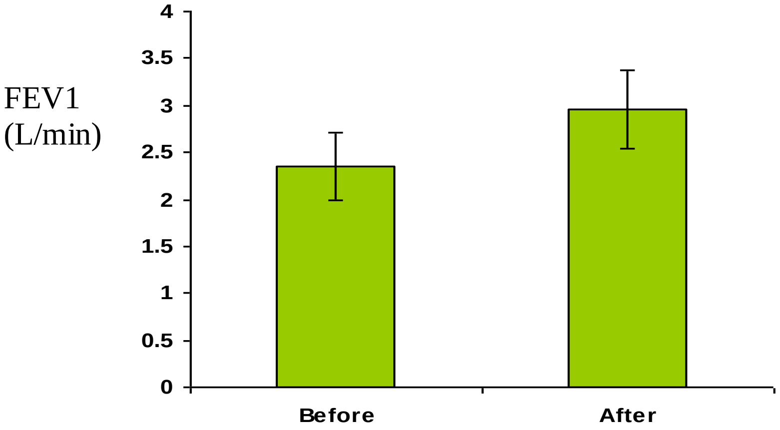
FVC - before pranayama showed 2.60±0.40 & after pranayama showed 3.20±0.43 which is statistically significant ($P<0.001$) compared to before pranayama.

Fig. 13: Comparison of breath holding time (sec) before and after 6 weeks pranayama



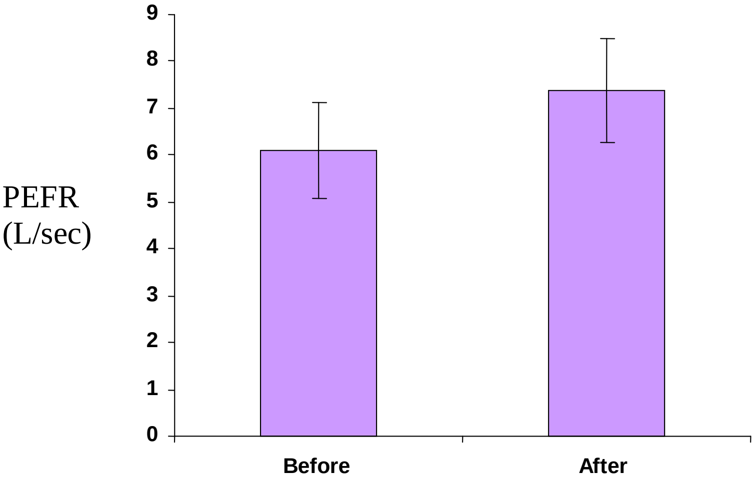
BHT - before pranayama shows 38.34±4.34 & after pranayama showed 56.62±9.01 which is statistically significant ($P<0.001$) compared to before pranayama.

Fig.14: Comparison of lung parameter FEV1 (L/min) before and after 6 weeks pranayama



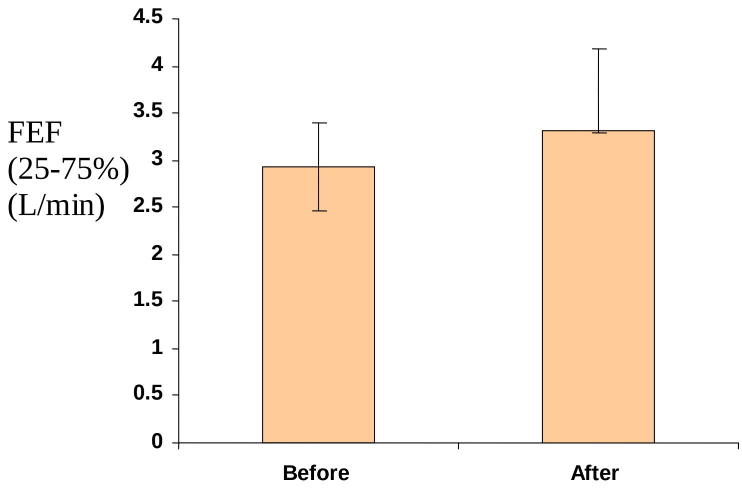
FEV1- before pranayama showed 2.36±0.36 & after pranayama showed 2.96±0.42 which is statistically significant (P<0.001) compared to before pranayama.

Fig.15: Comparison of lung parameter PEFR (L/sec) before and after 6 weeks pranayama



PEFR- before pranayama showed 6.09±1.03 & after pranayama showed 7.38±1.12 which is statistically significant (P<0.001) compared to before pranayama.

Fig.16 : Comparison of lung parameter before and after of FEF 25-75 %(L/min)



FEF (25%-75%) - before pranayama showed 2.93±0.47 & after pranayama showed 3.74±0.45 which is statistically significant (P<0.001) compared to before pranayama.

DISCUSSION

DISCUSSION

Pranayama is a type of yogic breathing exercise. It is a form of physiological stimulation. Regular practice of Pranayama is a form of adaptation to the repeated stimulus. Breathing is the only autonomic function that can be consciously controlled and is the key to bring the sympathetic and parasympathetic nervous system into harmony[9]. Breath is the only function through which we influence the involuntary nervous system, i.e. we can establish rhythms of breathing with our voluntary nerves and muscles that will affect the involuntary nervous system.[14]

Pulmonary function test (PFTs) is a valuable tool for evaluating the respiratory system. It is a simple screening procedure performed using standardized equipment to measure lung function.[13]

Pulmonary function tests have been studied in yoga and pranayama practitioners. It shows that regular practice of these long -term pranayama techniques proved to be beneficial for the human body and it also improves breath holding time.[34, 35] This study was designed to know the effect of short- term pranayama (6 weeks) techniques on pulmonary function parameters.

In our study, PFT values were recorded in young healthy subjects before and after 6 weeks of pranayama .The pulmonary function parameters FVC, FEV1, PEFR, FEF25-75% and Breath holding time (BHT) were found to be significantly increased. These results were consistent with other studies like Yadav A et al. (2009)[60], Upadhyay KD et al. (2008)[61], Chanavirut et al. (2006).[67]

All these studies explain that, during pranayama training, regular inspiration and expiration for prolonged period leads the lungs to inflate and deflate maximally and causes strengthening and increased endurance of respiratory muscles. [4,5,6,7] This maximum inflation and deflation is an important physiological stimulus for the release of surfactant and prostaglandins into alveolar spaces and thereby increasing lung compliance. [52,53] Stretch receptors reflexly decrease the tracheo- bronchial smooth muscle tone activity which leads to decreased air flow resistance and increased airway caliber which causes the dynamic parameters of lung function test to improve.

A study showed that after 2 weeks of pranayama practice FVC, FEV1, FEF 25-75%, PEFR values improved. In our study greater improvement of pulmonary parameters were observed. This may be due to involvement of young healthy adults (mean age group 25.76± 5.51 years) practicing 6 weeks of pranayama.[60]

A Study by Bhargava MR et al. showed a statistically significant increased breath holding time after pranayama practice. The same study explained that during pranayama training, regular inspiration and expiration for longer duration leads to acclimatization of central and peripheral chemoreceptors for both hypercapnea and hypoxia. [62] Acclimatization of stretch receptors of chest, bronchial walls and alveoli increase the synchronization between lung tissue and cortex. Prolonged inhalation in pranayama leads to increased breath holding time. [43,66]

A study by Upadhyay A et al. pranayama practice conducted for 4 weeks duration showed increased PEFR where as in our study with 6 weeks of pranayama practice, PEFR values showed greater improvement .[61] This showed that as duration of pranayama increases the pulmonary function test parameters also increases proportionately.

It was observed in another study by Bhavani et al. that pranayama produced immediate and significant reduction in auditory and visual reaction time indicating an improved sensory motor performance and enhanced processing ability of central nervous system.[64]

A study by Ravindra et al. on patient with premature ventricular complexes (PVC) and episodes of palpitations found that pranayama produced an immediate relief of palpitations and PVC. This improvement could be because of reduction of sympathetic reactivity attained by pranayama training.[65]

SUMMARY

AND

CONCLUSION

SUMMARY AND CONCLUSION

Pranayama is an ancient yoga technique. Regular practice of Pranayama integrates mind and body. It differs from other forms of exercises as it mainly focuses on sensations in the body. Pranayama thus acts directly on the various functions of the body and affords benefits in positive way.

We studied the effect of pranayama on pulmonary function tests and breath holding time in 26 male and 24 female who practiced pranayama in patanjali yoga center and SDUMC, Kolar.

In the study group, the first phase of recordings of pulmonary parameters were taken at the beginning of their course and Second phase of recording after 6 weeks of first phase of recording. The study group showed a statistically significant increase in FVC, FEV_1, FEF25-75%PEFR and BHT after 6 weeks of practice of pranayama.

Our study showed that pulmonary function test values improved after short term (6 weeks) pranayama practice. This could be because of:

1. Regular, slow and forceful inspiration and expiration for longer duration during pranayama practice leads to strengthening of the respiratory muscles.

2. Pranayama training causes improvement in expiratory power and decreases resistance to air flow in the lungs.

3. Pranayama training causes increase in voluntary breath holding time. This may be due to acclimatization of chemoreceptors to hypercapnea

BIBLIOGRAPHY

BIBLIOGRAPHY

1. Mishra SP. Yoga and Ayurveda. 2nd ed. 1997.
2. Malathi A, Damodaran A. Stress due to exams in medical students- Role of Yoga. Indian J Physiol Pharmacol 1999;43(2):218-224.
3. Bhavanani AB, Madanmohan, Udupa K. Acute effect of Mukh Bhastrika (yogic bellows type breathing) on reaction time. Indian J Physiol Pharmacol. 2003;47(3):297-300.
4. Madanmohan, Udupa K, Bhavanani AB, Shatapathy CC, Sahai A. Indian J Physiol Pharmacol 2004;48(4):461-465.
5. Madanmohan, Lakshmi J, Udupa K, Bhavanani AB. Effect of yoga training on handgrip, respiratory pressures and pulmonary function. Indian J Physiol Pharmacol 2003;47(4):387-392.
6. Raghuraj P, Telles S. Muscle power, dexterity skill and visual perception in community home girls trained in yoga or sports and in regular school girls. Indian J Physiol Pharmacol 1997;41:409-415.
7. Dash M, Telles S. Yoga training and motor speed based in a finger tapping task. Indian J Physiol Pharmacol 1999;43:458-462
8. Tran MD, Holly RG, Lashbrook J, Amsterdam EA. Effects of hatha yoga practice on health related aspects of physical fitness. Prev Cardiol 2001;4: 165-170.
9. Grover P, Varma VD, Pershad D, Verma SK. Role of yoga in the treatment of psychoneuron’s Bull. P.G.I. 1998;22(2):68-76.
10. Chakraborti, Ghosh, Sahana. In: Ghosh HN, editor. Text book of Human Physiology. 2nd ed. Calcutta: Mohendranath poul; 1984. p.1232-1235.

11. Telles S, Nagarathna R, Nagendra HR. Breathing through a particular nostril can alter metabolism and autonomic activities. Indian J Physiol Pharmacol 1994;38(2):133-137.

12. Udupa, Singh, Settiwar. Studies on physiological, endocrine and metabolic response to the practice of yoga in young normal volunteers. J Res Ind Med 1971;6(3):345-353.

13. Gildea TR .Pulmonary function testing. Adapted from American thoracic society: Single-breath carbon monoxide diffusing capacity (transfer factor).Recommendations for a standard techniques-1995 update. Am J Respir crit care Med .1995; 152:2185-2198.

14. Jain N, Srivastava RD, Singhal A. The effect of right and left nostril breathing on cardiorespiratory and autonomic parameters. Indian J Physiol Pharmacol 2005;49(4):469-474.

15. Warren M, Gold DM. Pulmonary function testing. In: Murray JF, Nadel JA, Mason RJ, Boushey HA Jr, editors. Textbook of Respiratory Medicine. 3rd ed. Philadelphia: Saunders; 2000. p. 781-882.

16. Fraser RS, Muller NL, Colman N, Pare PD, editors. Methods of functional investigation. In: Fraser and Pare's Diagnosis of diseases of the chest. 4th ed. Philadelphia: Saunders; 1999. p. 404-430.

17. Guyton AC, Hall JE, editors. Textbook of Medical physiology. 11th ed. Philadelphia: Saunders; 2006.

18. Martini PH. Fundamentals of Anatomy and Physiology. New Jersey: Prentice Hall; 1998.

19. Petty TL. John Hutchinson's Mysterious Machine Revisited. Chest 2002;121: 219 -223.

20. Ganong WF, editor. Review of Medical Physiology. (22): Boston: McGraw Hill; 2003.

21. Weinberger SE, Drazen JM. Disturbances of Respiratory Function. In: Kasper DL, Braunwald E, Fauci AS, Hauser SL, Longo DL, Jameson JL, editors. Harrison's Principles of internal medicine.16 ed. New York: McGraw-Hill; 2005.p.1498-1501.

22. Ghai CL, editor. Spirometry: a textbook of practical physiology. New Delhi: Jaypee brothers; 2005.

23. Crapo RO. Pulmonary function testing. N Engl J Med 1994;33(1):25-30.

24. American Association for Respiratory Care. Clinical Practice Guideline Spirometry, 1996 update. Respir Care 1996; 41(7):629-636.

25. Petty TL. Benefits of and barriers to the widespread use of spirometry. Curr Opin Pulm Med 2005; 2:115-120.

26. Gal TJ. Pulmonary Function Testing. In: Miller RD, editor. Miller's Anesthesia. 6th ed. Philadelphia: Elsevier Churchill Livingstone; 2005. p. 999-1026.

27. Cloutier M. The Respiratory System. In: Berne RM, Levy MN, Koeppen BM, Stanton BA, editors. Physiology. 5th ed. St Louis: Mosby; 2004. p. 443-536.

28. Pride NB. Tests of Forced Expiration and Inspiration. Clin Chest Med 2001; 22(4):599-622.

29. West JB. Respiratory Physiology-the essentials. Baltimore: Williams and Wilkins; 1979.

30. Gopal KS, Bhatnagar OS, Subramanian N, Nishith SD. Effect of yogasanas and pranayamas on blood pressure, pulse rate and some respiratory functions. Indian J Physiol Pharmacol. 1973;17(3):273-276.

31. Murthy KJR, Sahay BK, Sunitha M, Seetharamaraju P, Yogi R, Reddy V. Effect of yoga on ventilatory functions in normal healthy volunteers. Lung India. 1983;5:189-192.

32. Bhole MV, Karambelkar PV, Ghorote ML. Effect of yoga practice in vital capacity. Indian J Chest Dis 1970;12(1):32-35.

33. Nayar H , Mathur RM, Sampathkumar R. Effect of yogic exercises in human physical efficiency. Ind J Med Res 1975;63(10):1369-1376.

34. Joshi LN, Joshi VD, Gokhale LV. Effect of short term pranayama practice on breathing rate and ventilatory functions of lung. Indian J Physiol Pharmacol 1992;36(2):105-108.

35. Makwana K, Khirwadkar N, Gupta HC. Effect of short term yoga practice on ventilatory function tests. Indian J Physiol Pharmacol 1988;32(3):203-208.

36. Yadav RK and Das S. Effect of yogic practice on pulmonary functions in young females. Indian J Physiol Pharmacol. 2001;45(4):493-496.

37. Bijalani RL. Understanding medical physiology, 3rd ed. Noida: Jaypee brothers; 2004.

38. Murthy KRJ. Effect of pranayama (Rechka, Puraka and Kumbhaka) on bronchial asthma- An open study. Lung India 1984;2:187-191.

39. Nagarathna R, Nagendra HR. Yoga for bronchial asthma: a controlled study. British Med J 1985;291:1077-1079.

40. Nagendra HR, Nagarathna R. An integrated approach of yoga therapy for bronchial asthma: a 3-54 month prospective study. J Asthma. 1986;23(3):123-137.

41. Behera D, Jindal SK. Effect of Yogic exercises on bronchial asthma. Lung India 1990;4:18-189.

42. Anil Kumar K, Gnana Kumari K, Girija Kumari D, Shay BK, Murthy KJR. Immediate effects of Pranayama in airways obstruction. Lung India 1985; 2:77-81.

43. Bhargava MR, Gogate MG and Mascarenhas. A study of BHT and its variations following Pranayamic exercises. Clinician 1982;43-46.

44. Madanmohan, Udupa K, Bhavani AB, Vijayalakshmi P, Surendiran S. Effect of slow and fast pranayamas on reaction time and cardiorespiratory variables. Indian J Physiol Pharmacol 2005;49(3):313-318.

45. Bharagava MG, Gogate, Mascarenhas JF. Autonomic responses to breath holding and its variations following pranayama. Indian J Physiol Pharmacol 198;32(4):257-263.

46. Khanam AA, Sachdeva U, Guleria R and Deepak KK. Study of pulmonary and autonomic functions of asthma patients after yoga training. Indian J Physiol Pharmacol 1996;40(4):318-324.

47. American thoracic society. ATS statement snow bird workshop on standardization of of spirometry. Am Rev Respir Dis 1979;119:813-839.

48. Bhargwat AD, Shah KD. The Valsalva Manoeuver. J Assoc physicians India 1990;38(3):221-223.

49. Black LF, Hyatt RE. Maximal respiratory pressures: Normal values and relationship to age and sex. Am Rev Respir Dis 1969;99:696-702.

50. Murthy KN, Mariovaz. The development and Validation of or digital peak respiratory pressure monitor and its characteristics in healthy human subjects. Indian J physiol pharmacol 1999;43(2):186-192.

51. Rodahl AM, Brien O, Firth GR. Diurnal variation in performance of competitive swimmers. J Sports med phys fitness 1976;16:72-73.

52. Hilderbran JN, Georke J, Clements JA. Surfactant release exercised rat lung stimulated by air inflation. J Applied physiol 1981;51:905-910.

53. Smith AP. Prostaglandins and respiratory system prostaglandins; physiological, pharmacological and pathological aspects. Edited by Karim. SM 1976; 83 – 102.

54. Belman MJ, Gaesser GA. Ventilatory muscle training in the elderly. J Appl physiol 1998; 64(3):899-905.

55. Bharagava MG, Gogate, Mascarenhas JF. Autonomic responses to Breath holding and its variations following pranayama. Indian J Physiol Pharmacol 1998;32(4):257-263.

56. Bernard R. Fundamentals of Biostatistics. 5th ed. Duxbury; 2000.

57. Reddy VS. Statistics for Mental Health Care Research. Bangalore: NIMHANS publication.2005.

58. Sunderrao PSS, Richard J. An Introduction to Biostatistics, A manual for students in health sciences. 4th ed. New Delhi: Prentice hall of India; 2009.

59. Eng J. Sample size estimation: How many Individuals Should be Studied?. Radiology 2003; 309-313.

60. Yadav A, Savita S, Singh KP. Role of pranayama breathing exercises in rehabilitation of coronary artery disease patients. Indian J tradit knowl 2009;3:455-408.

61. Upadhyay KD, Malhotra V, Sarkar D, Prajapati R. Effects of alternate nostril breathing exercises on cardio respiratory functions. Nepal medical coll J 2008; 10(1):25-27.

62. Joshi LN, Joshi VD. Effect of forced breathing on ventilatory functions of the lung. J Postgrad Med 1998;44(3);67-69.

63. Madanmohan. The yoga review. Introducing yog to medical students: The JIPMER experience. 2008; 3:25-34.

64. Bhavanani. Pranayama effect on visual and auditory evoked potentials. Ind J Physiol Pharmacol 2003; 47:297-300.

65. Ravindra. Effect of Pranayama on cardiac respiratory system . International J cardiology 2006; 108:124-125.

66. Jerath R, Edry J, Barnes V, Jerath V. Physiology of long pranayamic breathing: Neural respiratory elements may provide a mechanism that explains how slow deep breathing shift the autonomic nervous system. Med Hypotheses 2008; 67(3):566-571.

67. Chanavirut R, Khaidjapho K, Jare P, Pongnaratorn P. Yoga exercise increases chest wall expansion and lung volumes in healthy Thais. Thai J Physiological sciences .2006; 19(1):1-7.

68. American collage of occupational and environment medicine. Evaluating pulmonary function change over time .J occupation environment Med 2010; 42.

69. Yoga Vidya Dham ,Pranayama :Yoga Vidya Dham (updated on oct 27,2010). Pranayama (from Hatha yoga and Astanga yoga) ;(about 3 screens) available from http://www.yoga point.com/info/Pranayama.htm.

70. Weinberger SE, Rosen IM. Harrison’s principles of internal medicine. 17 (1); 1586.

ANNEXURE

ANNEXURE

VOLUNTEERS	AGE IN YEARS	SEX	FVC (L/min)		FEV1 (L/min)		PEFR (L/sec)		FEF (25-75%) L/min		BHT(Sec)	
Code			PRE	POST	PRE	P0ST	PRE	POST	PRE	POST	PRE	POST
1	26	M	3.62	4.24	3.12	3.69	6.71	7.98	3.90	4.77	45	75
2	19	F	2.92	3.42	2.90	3.61	5.12	6.66	3.79	4.21	36	42
3	28	M	2.67	3.58	2.41	3.44	7.45	8.88	3.62	4.41	42	66
4	33	M	3.34	3.78	3.21	3.57	8.76	9.10	3.87	5.00	36	46
5	28	F	2.65	3.06	2.46	2.76	5.70	6.23	3.16	4.00	45	68
6	27	F	2.51	2.89	2.34	2.67	5.25	5.99	3.10	3.97	34	54
7	27	F	2.45	2.84	2.22	2.53	4.31	5.34	3.15	3.81	36	46
8	34	M	3.84	4.34	3.05	4.10	7.89	8.56	2.93	3.78	39	54
9	35	M	2.21	2.62	1.87	2.32	6.99	7.92	2.65	3.99	30	43
10	35	M	2.30	3.06	2.22	2.76	5.70	8.77	3.32	4.04	36	42
11	19	F	2.56	3.14	2.50	305	5.33	6.09	2.54	3.12	35	43
12	19	F	2.35	2.80	2.01	2.72	5.65	6.23	2.81	3.43	36	50
13	35	M	3.46	3.74	2.97	3.63	9.06	10.53	3.06	3.56	45	66
14	33	M	2.67	3.33	2.41	3.17	7.45	8.88	3.15	3.89	38	50
15	28	M	2.54	3.27	2.11	2.84	5.88	6.76	3.56	4.32	35	48
16	34	M	2.67	3.25	2.43	3.12	5.65	6.22	3.23	3.88	38	52
17	33	M	2.78	3.39	2.75	3.11	6.85	7.77	3.12	3.90	36	59
18	20	F	2.12	2.48	1.91	2.32	6.10	8.33	2.76	3.89	39	48
19	26	M	3.07	3.75	2.45	3.20	6.75	7.88	3.43	3.89	45	57
20	23	F	2.35	2.87	2.13	2.56	5.78	6.45	3.16	3.71	34	55
21	32	M	2.28	3.02	2.09	2.90	7.06	8.96	3.34	4.02	45	60
22	30	F	2.13	2.76	1.98	2.65	5.60	7.02	3.23	3.89	40	59
23	29	M	2.53	3.32	2.19	2.79	6.54	8.51	2.32	3.90	43	56
24	18	M	2.26	3.16	2.06	2.74	5.96	7.88	2.01	3.46	34	56
25	25	F	2.40	2.76	2.40	2.69	4.47	6.32	2.34	3.00	39	60
26	32	M	2.67	3.33	2.41	2.86	7.45	8.11	3.24	3.96	45	69

27	**28**	**M**	**2.43**	**2.68**	**2.30**	**2.60**	**5.26**	**7.86**	**3.27**	**3.98**	**38**	**71**
28	**34**	**M**	**2.92**	**3.66**	**2.64**	**3.01**	**6.81**	**8.17**	**2.76**	**3.86**	**42**	**65**
29	**32**	**F**	**2.16**	**2.89**	**1.91**	**2.41**	**5.12**	**7.00**	**2.02**	**3.21**	**32**	**49**
30	**25**	**M**	**2.78**	**3.57**	**2.60**	**3 .32**	**6.09**	**7.91**	**2.56**	**3.34**	**37**	**58**
31	**22**	**M**	**2.90**	**3.43**	**2.80**	**3.37**	**6.98**	**7.64**	**2.66**	**3.56**	**35**	**62**
32	**19**	**F**	**2.34**	**2.82**	**2.00**	**2.69**	**6.01**	**7.87**	**2.04**	**2.87**	**40**	**63**
33	**23**	**M**	**2.68**	**3.43**	**2.11**	**2.84**	**5.96**	**7.89**	**2.88**	**3.75**	**43**	**56**
34	**27**	**F**	**2.67**	**3.01**	**2.45**	**2.88**	**5.05**	**6.30**	**2.59**	**2.87**	**30**	**45**
35	**19**	**F**	**2.55**	**2.90**	**2.30**	**2.80**	**5.07**	**6.54**	**2.89**	**3.32**	**34**	**55**
36	**19**	**F**	**2.05**	**2.67**	**1.90**	**2.43**	**4.78**	**5.87**	**2.00**	**2.87**	**39**	**48**
37	**19**	**M**	**2.90**	**3.56**	**2.78**	**3.33**	**7.09**	**8.77**	**3.12**	**3.89**	**43**	**67**
38	**19**	**F**	**1.91**	**2.45**	**1.78**	**2.34**	**5.09**	**6.11**	**3.08**	**3.56**	**38**	**50**
39	**21**	**M**	**2.40**	**2.98**	**2.21**	**2.67**	**5.71**	**6.65**	**2.34**	**3.39**	**34**	**62**
40	**23**	**M**	**2.78**	**3.56**	**2.50**	**3.31**	**6.57**	**8.03**	**3.24**	**4.03**	**38**	**60**
41	**25**	**F**	**2.59**	**3.01**	**2.34**	**2.78**	**5.89**	**7.01**	**2.44**	**3.45**	**40**	**67**
42	**23**	**F**	**2.34**	**3.32**	**2.11**	**3.12**	**4.98**	**5.78**	**3.08**	**4.34**	**33**	**40**
43	**21**	**F**	**2.56**	**3.45**	**2.34**	**3.33**	**5.78**	**6. 70**	**3.21**	**3.56**	**35**	**56**
44	**21**	**F**	**2.36**	**2.98**	**2.12**	**2.89**	**5.50**	**7.00**	**2.87**	**3.39**	**40**	**67**
45	**25**	**F**	**2.11**	**3.00**	**2.01**	**2.70**	**6.00**	**7.43**	**2.67**	**3.67**	**42**	**56**
46	**21**	**F**	**2.44**	**2.99**	**2.39**	**2.81**	**5.62**	**6.34**	**2.33**	**3.45**	**38**	**62**
47	**28**	**M**	**3.20**	**3.88**	**3.09**	**3.76**	**7.08**	**8.17**	**3.33**	**4.20**	**41**	**68**
48	**28**	**M**	**3.02**	**3.78**	**2.78**	**3.56**	**6.45**	**8.24**	**2.99**	**3.86**	**46**	**70**
49	**19**	**F**	**2.34**	**2.86**	**2.12**	**2.67**	**4.92**	**6.08**	**2.88**	**3.56**	**43**	**65**
50	**23**	**M**	**2.68**	**3.43**	**2.11**	**2.84**	**5.96**	**7.89**	**2.88**	**3.75**	**43**	**56**

PROFORMA

Code	SL.No	Name	Age	Sex	Height cms	weight kgs

Tests	Before pranayama				After pranayama			
	1	2	3	4	1	2	3	4
FVC								
FEV_1								
FEF(25-75%)								
PEFR								
BHT								