NORMS FOR FORCED & SLOW VITAL CAPACITY IN ADULT DRAVIDIAN POPULATION

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INTRODUCTION

Respiration is the act of inhaling and exhaling air in order to exchange oxygen for carbon-dioxide. Apart from the primary aim of sustaining life, it is the source for the speech production. Pulmonary measures like lung volumes and lung capacities are useful in understanding the working of respiratory system. Both lung volumes and lung capacities are responsible for breathing for life and breathing for speech. Hence respiration serves both a life sustaining function and a speech production function. Any abnormality in respiration involves in coordination of breathing patterns for speech production.

The respiratory features important for speech production are pressure, volume, flow and chest wall shape. Pressure refers to the forces generated by the respiratory process. Volume refers to the amount of air in the lungs and airways. Flow refers to the measure of volume of air moving in a certain direction over a period of time. Chest wall shape refers to the positioning of the chest wall (ribcage, diaphragm and abdominal muscles) for speech breathing activity.

The steady outflow of air causes vibration in the vocal folds to produce voice by the modification of the vocal tract. It has been found that during speech the abdomen is smaller and the rib cage is larger than in their respective relaxation positions. This positioning is efficient for speech, because when the abdominal wall moves inward it pushes the diaphragm upward and expands the lower rib cage. This allows the diaphragm to make quick, strong contractions, which facilitates the quick inspirations and the constantly changing pressures needed for speech (Hixon, 1973).

Speech Language Pathologist needs to focus on respiration as it relates to speech production and also there is a need to evaluate the respiratory system as a part of voice evaluation. Studies in the physiopathology of the lungs are aimed primarily at the investigation of the so called functional weakness of the respiratory organ. In the assessment of pulmonary functions, Spirometry is commonly used. Spirometers are useful in determining volumes such as vital capacity and tidal volume. Vital capacity is used as an index of lung capacity for speech and voice functions. A person does not use the entire vital capacity in functional, quite respiration or for speech. Thus a small percentage of total vital capacity is used in quite breathing. In normal healthy persons, the volume of air in the lungs primarily depend on body size and build however the body position also influences the pulmonary measures. It has been found that most of the volumes and capacities decrease when a person is lying down rather than standing.

Kent (1994) compiled norms for many aspects of respiration including standards of measurement, appropriate instrumentation, capacities and respiration rates by age and gender, physiological requirements for speech production, body size factors related to respiration, flow volume relationships and effects of smoking on the respiratory tract. He reported that between 25% and 40% of vital capacity is used in speech by typical adults.

The pulmonary measures are influenced by a number of factors particularly height, age, usual habitat, geographical condition and ethnic and racial origin. In different parts of the world several investigators have investigated the different lung function measurements and established the normal standards (Cotes and Ward, 1966; Da Costa, 1971, Sider and Peters 1973). In a comparative study of lung function among the American, European, Jordanian, Negro and the Pakistani subjects, it was found that the former three groups were superior to the remaining groups. The vital capacity varies with age, sex, height, weight, body surface area, body build and other factors (Zemlin, 1981). Hutchinson (1979) had explained the relationship between lung capacity and body size and weight.

In the Indian context, such studies were carried out for the north-west region (Jain & Ramaiah 1969, Mathew, 1984, Verma, 1983) and southern geographical region (Kamat et al 1982, Reddy and Shastry 1944). These studies observed that the Spirometric functions varied between these two populations. Chatterjee (1988) reported that the Spirometric functions of Eastern region Indians are comparable to north-west Indians and superior to southern Indians. Vital capacity can be predicted on height and weight and there is no significant difference between the vital capacities and mean flow rates for both males and females (Krishna Murthy, 1986). Sudhir Banu (1987) found significant differences in mean airflow rates in dysphonics. It has been found that mean vital capacity values in Indians were significantly lower than the western subjects (Battacharya 1963).

Need for the study

Although several studies provide important information on the normal standards for air volume measurements among different population in different parts of the world, there are no established norms for air volume measurements in Dravidian population using a Spirometer. For a speech language pathologist, such norms are especially important for estimating the respiratory capacity and efficiency in patients with various voice disorders and speech disorders.

Aim of the study

To establish norms for some of the air volume measurements using a dry Spirometer in the Dravidian population.

Objectives of the study

1. To establish normative values for Forced Vital Capacity (FVC), Slow Vital Capacity (SVC) and their related parameters for adult Dravidian population.

2. To obtain these respiratory measures in sitting and standing postures and the comparison of the same.
3. To compare the respiratory measures obtained across age groups and across gender.

Brief Method

Subjects: 120 healthy adults in the age range of 20-40years who are natives of south India were selected for the study. Subjects were subdivided into two groups i.e 20-30years and 30-40years. Each group consisted of 60 subjects with an equal number of male and female subjects.

The subjects were selected based on the following criteria:

1. Should be of Dravidian origin
2. Should be free from any history of respiratory, circulatory and neuromuscular diseases.
3. Should be non-smokers & non- alcoholics (heavy)
4. There should be no history of any serious illness & syndromatic conditions
5. Should be free from any obesity related problems

Instrumentation and Parameters

The instrument used in the study was Spirometer Helios 501 (RMS). The following measures were deduced from the study:

- FVC (Forced Vital Capacity) in liters
- FEV_1 (Forced Expiratory Volume in 1 Second) in liters
- FEV_1 / FVC (in %)
- SVC (Slow Vital Capacity) in liters
- TV (Tidal Volume) in liters

Implications of the study

1. The norms serve as a reference standard for estimation of lung volume among subjects with voice disorders, chronic obstructive pulmonary disease like asthma etc.
2. The norms obtained can be applied for further research on comparison of smokers vs. non-smokers, thereby helpful to study the effect of smoking on lung functions.

Limitations of the study

1. Norms were obtained for only adult subjects in the age range of 20-40 years.
2. Only few respiratory parameters were considered in the study.

CHAPTER II

REVIEW OF LITERATURE

The ability to speak depends on a steady outflow of air that is vibrated by the vocal folds to produce a basic sound, which is then further modified by the articulators to generate the specific speech sounds of whatever language is being spoken. Without this outflow, there would be no speech. The air is subjected into the lungs for breathing and for speech purposes. Hence the air is used for life sustaining purposes.

For life purposes, the main function of respiration is to provide oxygen to the cells of the body and to remove carbon dioxide from them. The respiratory features important for speech production are pressure, volume, flow and chest wall shape. Pressure refers to the forces generated by the respiratory process. Volume refers to the amount of air in the lungs and airways. Flow refers to the measure of volume of air moving in a certain direction over a period of time. Chest wall shape refers to the positioning of the chest wall (ribcage, diaphragm and abdominal muscles) for speech breathing activity.

The steady outflow of air causes vibration in the vocal folds to produce voice by the modification of the vocal tract. It has been found that during speech the abdomen is smaller and the rib cage is larger than in their respective relaxation positions. This positioning is efficient for speech, because when the abdominal wall moves inward it pushes the diaphragm upward and expands the lower rib cage. This allows the diaphragm to make quick, strong contractions, which facilitates the quick inspirations and the constantly changing pressures needed for speech (Hixon, Goldman and Mead, 1973).

Basically, there are four changes that occur when we switch from breathing for life to breathing for speech: the location of air intake, the ratio of time for inhalation versus exhalation, the volume of air inhaled per cycle and the muscle activity for exhalation.

CHANGE	LIFE	SPEECH
Location of air intake	Nose	Mouth
Ratio of time for inhalation versus exhalation	Inhaling: 40% Exhaling: 60%	Inhale: 10% Exhale: 90%
Volume of air	500 cc 10%VC	Variable, depending on length and loudness of utterance, 20 to 25% VC
Muscle activity for exhalation.	Passive: Muscles of thorax and diaphragm relax	Active: thoracic and abdominal muscles contract to control recoil of ribcage and diaphragm.

Table 1: Showing respiratory changes occurring during breathing and speaking.

RESPIRATION

Basically we move air into and out of the lungs by increasing and decreasing the air pressure inside the lungs. When air pressure inside the lungs, the alveolar pressure is negative, air from the atmosphere is forced to enter the respiratory system, because as air moves from an area of higher pressure to an area of lower pressure. This is called inhalation or inspiration. When alveolar pressure is positive, air from inside the lungs is forced out of the respiratory system to the atmosphere. This process is called exhalation or expiration.

Inhalation

The phase of respiration during which air flows into the lungs is referred to as inspiration or inhalation. To bring air into lungs, the alveolar pressure must become negative so that air will be forced to flow into the respiratory system. To decrease alveolar pressure, there should be increase in volume of the thoracic cavity and lungs. This is done by contracting the diaphragm, which flattens out, increasing the vertical dimension of the thorax. Simultaneously, the external intercostal muscles contract, pulling the entire rib cage upward and slightly outward. This increases the back -to-front and side-to-side dimensions of the thorax. The lungs, attached by means of pleural linkage, are pulled in the same direction as the thoracic cavity and therefore increase in volume. As soon as the lungs begin to expand, the alveolar pressure falls below atmospheric pressure, reaching around -1 to -2 cm H_2o at the height of inspiration (Zemlin, 1981). As the alveolar pressure decreases, air from the atmosphere is forced into the respiratory system through either the mouth or nose. The air travels throughout the bronchial tree, eventually reaching the alveoli in the lungs. There the fresh oxygen diffuses into the blood capillaries surrounding the alveoli and is carried by the circulatory system to every cell in the body.

Exhalation

The reverse process occurs in exhalation. For air to exit the respiratory system, the must be higher than atmospheric pressure, so the volume of the lungs must decrease. To achieve this, the diaphragm relaxes back to its dome-shaped position, decreasing the vertical dimension of the thorax. The external intercostal muscles relax, allowing the ribcage to return to its original position, which decreases the back-to-front dimensions of the thorax. The relaxation of the diaphragm and ribcage gives rise to elastic recoil forces. Correspondingly the lungs also decrease their volume. As lung volume decreases, alveolar pressure increases to about +2cm H_2o relative to atmospheric pressure. Air carrying carbon dioxide (CO_2) brought to the lungs by the circulatory system, is forced out of the lungs and respiratory system until the alveolar pressure reaches atmospheric levels. At the end of each inhalation and each exhalation the alveolar pressure equals the atmospheric pressure and for a brief instant air does not move either into or out of the system. The cycle of breathing in and out then begins again.

Rate of breathing

The cycles of inhalation and exhalation start at the instant of birth and continue until the instant of death. The process occurs when we are awake and asleep, when we breathe vegetative for life and when we modify our breathing for speech. Differences in breathing between children and adults occur because the structures and functions involved in respiration mature from infancy through childhood. Numerous anatomical and physiological changes occur during the first year of life, including the following: the alveoli increase in number and size; the alveolar ducts increase in number; the alveolar surface area increases; lung size and weight increase; the thoracic cavity enlarges and changes in shape; the angle of the ribs changes with upright posture; ribcage muscle bulk increases; and pleura becomes more sub atmospheric (Boliek, 1996). Maturation of the nervous system also contributes to the development of more mature breathing patterns with increasing age.

PULMONARY DIVISIONS

Respiration is the product of a number of forces and structures and to make sense volumes and capacities of the lungs are defined. Volumes are the accurate estimate of the amount of the air each compartment can hold. Capacities refer to the combination of volumes that express physiological limits. Volumes are discrete, whereas capacities represent functional combination of volumes. A system of classifying certain volumes of air in relation to respiration was established in 1950.

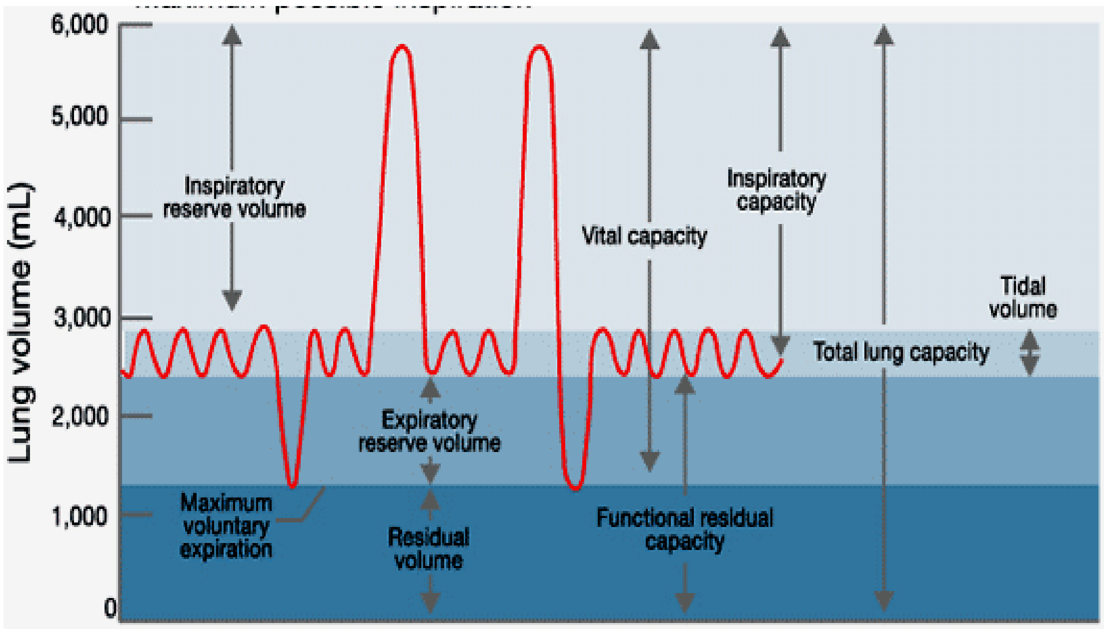


Fig 1: Shows various lung volumes and capacities

Lung volumes

Tidal volume (TV): The volume of air inhaled and exhaled during any single respiratory cycle is referred to as tidal volume. It varies as a function of physical exertion, body size and age. Quite tidal volume as an average for an adult male at rest is 750cc. while engaged in light work, the adults has an average tidal volume of 1670cc and during heavy work, their tidal volume averages 2030cc (Zemlin,1998). This suggests that work demands an increased oxygen expenditure, which in turn, will be reflected in the value of an individual’s tidal volume. In general, females inhale and exhale less air during each cycle of breathing than do males, about 450cc for quite breathing (Siekel, King and Drumwright, 1997).

Inspiratory reserve volume (IRV): The quantity of air which can be inhaled beyond that inhaled in a tidal volume cycle is called inspiratory reserve volume. The value for adults ranges from about 1500cc to 2500cc.

Expiratory reserve volume (ERV): It is the amount of air that can be forcibly exhaled following a quite or passive exhalation. Usually amount to about 1500cc and may go as high as 2000cc in a young adult.

Residual volume (RV): It is the volume of air remaining in the lungs and airways even after a maximum exhalation. No matter how forceful is the expiration; there is a volume of air (about 1.1liters) that cannot be eliminated.

Dead space air: It is the air in the conducting passage ways that cannot be involved in the gas exchange because of the absence of the alveoli. In adults it has a volume of about 150cc, but also varies with age and weight. The volume associated with dead air is included in the residual volume, because both are associated with air that cannot be expelled.

Lung capacities

Vital Capacity (VC): The sum of tidal volume, inspiratory reserve and expiratory reserve volumes, which represent the quantity of air exhaled after deep inhalations, is known as *vital capacity*. Vital capacity is the combination of IRV, ERV and TV i.e. it represents the total volume of air that can be exhaled after a maximal inspiration.

$$VC=IRV+ERV+TV$$

The quantity of vital capacity in the adult males ranges from 3500 cu cm to 5000 cu cm. The maximum volume of air that may be exhaled following maximum inspiration ranges between 3- 5 liters. Young male adults have a vital capacity of about 4.6 liters and females have 3.1 liters (Zemlin, 1981). The volume of air in the lungs depends on strength of the respiratory musculature and disease; body size and build; position of the body.

Respiratory capacities vary with posture and body size with a typical total lung capacity in the male adult being 5- 7 liters. When lying down, as a result of the abdominal viscera pressing upward against the diaphragm, and because the pulmonary blood volume increase, the volume and capacities of air decrease. The value of vital capacity may vary considerably due to body build and the amount or exercise or heavy-duty work. An athlete’s vital capacity is 6 or7 liters. This is 30 -

40 percent above normal. For strenuous exercises, such as pushing, lifting, etc, more air is needed. At quiet breathing, and at rest, air is exchanged about twelve times a minute. At rest both females and males have no significance difference in breathing rate but during heavy work, the rate is increased to 26 breaths per minute for males and 30 breaths per minute for females. At normal quiet breathing approximately 0.5 liters is inspired and expired at each breath (Zemlin, 1981).

Functional residual capacity (FRC): It is the volume of air remaining in the body after a passive exhalation. In the average adult it is about approximately 2100ml.

$$FRC=ERV+RV$$

Total lung capacity (TLC): It is the sum of all the volumes, totaling approximately 5100cc

$$TLC=TV+IRV+ERV+RV$$

Inspiratory capacity (IC): It is the maximum inspiratory volume possible after a tidal expiration. This refers to the capacity of the lungs for the inspiration and represents approximately 3000cc in adults.

$$IC=TV+IRV$$

Hence both lung volumes and lung capacities are responsible for breathing for life and breathing for speech. Hence respiration serves both a life sustaining function and a speech production function. Any abnormality in respiration involves in coordination of breathing patterns for speech production.

DEVELOPMENT OF LUNG VOLUMES AND CAPACITIES

In general lung volumes and capacities increase from infancy through puberty, and adult values are apparent by age 16. Lung volumes and capacities stay stable until the later adult years, and they start to decrease with advancing age.

Hoit and Hixon (1987) provided averages for lung volumes and capacities for three age groups, which shows that both vital capacity and expiratory reserve volume decrease somewhat with increasing age. This decrease may be implicated in some kinds of speech problems.

Lung volumes and capacities are often expressed as percentages of VC. The resting expiratory level is around 35 to 40% VC. This means that we can inhale 60 to 65% more air above the REL in order to fill the lungs to their maximum capacity. Conversely, at this point the lungs still hold 35 to 40 % of air that could be breathed out. Below 35 to 40% VC, the individual is drawing on ERV.

IMPORTANCE OF LUNG VOLUMES AND LUNG CAPACITIES

It is necessary to understand various aspects of pulmonary physiology described in terms of different volumes. “Air in the lung is divided into four primary volumes and four capacities (which overlap the volumes) that are altered in disease.

The vital capacity (VC=4800cc) is the maximal amount which can be expelled after full inspiration. The total lung capacity (TLC=6000cc) is the amount of air in the lung after maximal inspiration. The timed vital capacity (TVC) measures the rate at which the vital capacity (VC) can be emptied from the lungs. For example, forced expiration, 83% of the VC (about 4000cc) can be exhaled in one sec and 94% (about 4500cc) within three seconds. This measure of pulmonary function may also be termed the forced expiratory vital capacity (FEVC) and subdivided into volumes per unit time. The forced expiratory volume in the first second exceeds the volume exhaled in the second in a series of progressive volume reductions through the fifth (normal) to seventh (obstruction) seconds. The forced expiratory volume in the third second (FEV3) exceeds the volume in the first second (FEV1) because FEV3 summates the air volume exhaled in the first, second and third seconds.

Some research studies report that the maximal breathing capacity (MBC) is the greatest ventilatory volume a person can sustain for 12 seconds.

Representative values are 150 liters per minute for men and 100 liters per minutes for women. The respiratory system has substantive reserve capacity, as the resting breathing rate is 12 breaths per minute, moving only 7200cc of air per minute. The amount of air available for an individual for the purpose of voice phonation depends upon the vital capacity of an individual.

Hirano (1981) states, while discussing the aerodynamic tests, “The aerodynamic aspects of phonation are characterized by four parameters: sub glottal pressure supra glottal pressure, glottal impedance and the volume velocity of the airflow at the glottis. The values of these parameters vary during one vibratory cycle according to the opening and closing of the glottis. These rapid variations in the values of aerodynamic parameters cannot usually be measured in living humans because of technical difficulties”.

As it is difficult to measure these aerodynamic parameters most often the researchers and clinicians concerned with voice production resort to the measurement of vital capacity and mean airflow rate. These two parameters are considered as important measures, as they reflect (1) the total volume of air available for phonation, thus indirectly depicting the condition of the respiratory system. (2) the glottal area during the vibration of the vocal cords, in terms of flow rate, which in turn would show the status and functioning of the laryngeal system.

High lung volume helps in sustaining the vowel for a longer duration. A constant pressure drop across the glottis is required for a steady sound source; therefore sub glottal air pressure immediately rises and remains at a relatively constant level through out phonation. The respiratory system maintains not only a constant sub glottal air pressure but also a constant flow of air through the glottis. As air escapes, the lungs must decrease in size continuously so that sub glottal air pressure and glottal air flow can be maintained. To continue steady phonation for a long time, it is necessary to start at a high lung volume and end with a low lung volume (Bouhuys, Proctor and Mead, 1966; Mead, Turner and Mackem, 1968). Therefore large lung volume, better airflow rate will help in sustaining voice for a longer duration.

Sub glottic air pressure is some what difficult to measure, since the measuring device must be located below the glottis in the trachea in order to record the pressure built up when the vocal folds close. It is not obtained routinely in clinical assessment of phonation.

Schneider and Baken (1984) have reported the influence of lung volume on the relative contributions of glottal resistance and expiratory force to the regulation of sub glottal pressure. That is, lung volume does influence the consistency and strength of relationship between airflow, and intensity and pitch.

Therefore it is important to measure the total volume of air which can be expelled after full inspiration, and the total volume of air the patient uses in phonation. These measures are vital capacity (VC) and mean airflow rate (MFR) respectively.

VITAL CAPACITY IN SPEECH

The normal speaker uses only a small amount of his total vital capacity for speaking. Research studies have indicated that the normal speaker uses only about twice the air volume for speech that he uses for a quite, easy normal (or tidal) breathing. It has long been assumed that superior vocal ability for example, as in professional singers arose from a higher than average or normal vital capacity. Some studies conclude that significantly larger vital capacity values were found in well trained athletes and professional singers. Researchers studied the lung volumes of singers and found no significant differences between singers and non-singers; and they also found that the lung volumes did not vary significantly with various positions like sitting, standing, etc. Gould and Okamura (1973), from a study of static lung volumes in singers, concluded that there may be a specific correlation between the vital capacity and period of training. Sheela (1974) found that there was no significant difference in vital capacities between trained and untrained singers.

Yanagihara and Koike (1967) have related vital capacity to phonation volume; while Hirano, Koike and Von Leden (1968) have indicated a relationship between vital capacity and maximum phonation duration. In the former study, it was reported that the phonation volume, and the ratio of phonation volume to vital capacity both decreases as the subjective pitch level decreases. Thus a correlation between vital capacity and phonation volume capacity and phonation volume was reported with correlation coefficients ranging from 0.59 to 0.90. Research studies correlated phonation quotient (vital capacity to maximum phonation duration) with the flow rates in normal subjects, indicating that, higher flow rates were generally associated with shorter phonation durations or longer vital capacities. Studies found that singers designated as having "poor quality", to be having smaller vital capacities than singers categorized having "good" or "average" quality.

FACTORS AFFECTING VITAL CAPACITY

There are several variables which affect the vital capacity. The vital capacity varies with geographical area. Krishnan and Vareed (1932) have reported low vital capacity is south Indians. They attribute this low vital capacity not to race but to the warm climate, less tendency for exercise, low metabolism, and poor chest expansion. The vital capacity varies with age, weight, height and body surface, i.e the vital capacity can be calculated statistically based on height and weight data. Krishnan and Vareed (1932), Verma et al (1983), Jain and Ramaiah

(1969) have calculated lung capacity based on age, height, weight and body surface area for men and women in different age ranges in the Indian population.

Zemlin (1981) has reported that the vital capacity varies with age, sex, height, weight, body surface, body build, the amount of exercise and other factors. Hutchinson (1980) has demonstrated the relation between lung capacity and body size and weight. He indicated that vital capacity and body size are correlated with arithmetical progression, and that the age and weight seem to be significant only in extreme cases of variation, the circumference of the chest having no immediate influence on the vital capacity.

Effects of body position on lung volumes and capacities

In normal persons the volumes and the capacities of the lung depends primarily on the body weight and build, however position of the body will also influence pulmonary values. Most of the volumes and the lung capacities decrease when a person is lying down rather than standing. Two factors contribute to this they are

1. There is a tendency for the abdominal viscera to press upward against the diaphragm when a person is lying down.
2. The pulmonary blood volume increases in the lying position, which decreases the space available for the pulmonary air.

Hixon, Goldman and Mead (1973) investigated the effects that various body positions had on respiratory behavior during oral reading. They found lung capacities at resting expiratory level to be about 20% of vital capacity lower in the supine position than in the upright position that speech was produced at a lower level. In the upright position, gravity acts in an expiratory direction on the ribcage and in an inspiratory direction on the abdomen. The effect is mainly on the abdomen, being greater at low than at high lung volumes because the height of the abdomen is greater and its walls less stiff in the former situation (Agostoni and Mead, 1964). Compared to the upright to supine position there is less gravitational effect with changes in lung volume in the supine position because the height of the abdomen is less (Agostoni and Mead, 1964).

Pierson, Dick and Petty (1976) obtained Spirograms from 235 subjects in standing and sitting positions revealed small differences for the forced vital capacity (FVC) and forced expiratory volume in one second (FEV1). Statistically significant differences were not found for the mean forced expiratory flow during the middle half of the FVC (FEF25-75%, or maximal mid expiratory flow) and FEV1/FVC. Sitting values were, on the average, higher for determinations greater than FVC of 2.14 Liters, FEV1 of 1.68 Liters, FEF25-75% of 2.16 Liters/sec, and FEV1/FVC of 75.7%. On the average, subjects with less than these values performed slightly better in the standing position.

Lalloo, Becklake and Goldsmith (1991) examined the effect of the standing versus the sitting position on Spirometric indices in 94 healthy non-obese adult subjects (41 men and 53 women) . On average all the Spirometric indices examined, except the peak expiratory flow rate (PEFR), were higher in the standing compared to the sitting position although the change was only significant at the 5% level for FEV1 in women. The fall in FEV1 with the change in position was statistically related to the ponderal index but not to age, height or the initial lung function level. A uniform posture i.e. standing is recommended for conducting the Spirometric studies.

Townsend (1984) empirically examined the effects of sitting versus standing posture on the Spirometric forced expiratory volumes. He examined 90 middle-aged male subjects alternated the sitting-standing and standing-sitting testing sequence between subjects to avoid confounding by testing order effects. The major findings were that forced expiratory volumes in one and in six seconds and forced vital capacity were significantly larger ($p < 0.001$) in the standing than in the sitting posture, with mean standing minus sitting differences ranging from +0.06 to +0.08 Liters for the 3 indexes. The larger expired volumes measured in the standing position in this study were probably due to the subjects taking slightly larger inspirations in this posture than in the sitting position.

Earlier studies indicated that there was a significant but small difference in Spirometric values between sitting and standing position in the normal population. Vilke et al (2000) investigated forced vital capacity (FVC), forced expiratory volume in the first second (FEV1), and maximum voluntary ventilation (MVV) in the sitting, supine, and prone positions in 20 healthy men, aged between 18-50 years. Comparing sitting to supine and prone positions, there was a significant decline in the Spirometry values. They found that in healthy men with BMI < 30 kg/m^2, changing from the sitting to supine or prone position results in statistically significant change in respiratory pattern. However, all Spirometry values in each position were normal by American Thoracic Society definitions.

Although several studies provide important information on the normal standards for air volume measurements among different population in different parts of the world, there is no established norms for air volume measurements in Dravidian population. For a speech language pathologist, such norms are especially important for estimating the respiratory capacity and efficiency in patients with various voice and speech disorders.

Thus the review of literature indicates that the vital capacity and mean air flow rate, among other aerodynamic factors, play an important role in speech production and also the duration for which an individual can sustain phonation.

RESPIRATORY MEASURE ANALYSIS

The respiratory measures include pressure, volume, flow and chest wall shape. Pressure refers to the forces generated by the respiratory process. Volume refers to the amount of air in the lungs and airways. Flow refers to the measure of volume of air moving in a certain direction over a period of time. Chest wall shape refers to the positioning of the chest wall (ribcage, diaphragm and abdominal muscles) for speech breathing activity. These are measured in three categories i.e. air pressure, air flow, air volume.

Air pressure

It shows pressure variation in terms of millimeters or centimeters of water. Manometer is mostly used for this purpose. It is very informative for patients with neurological disorder like cerebral palsy or defective VP mechanism. It is assumed that an individual who can sustain pressure of equal to 5cm h_2o for 5sec has sufficient pressure for speech production.

Air flow

Flow is the measure of movement of volume (quantity) through a given area in a unit time. Liters on millimeters per sec are commonly used units. Pneumotachograph is used for this purpose.

Air volume

Being Speech Language Pathologist, we are basically concerned with the "amount of air used for a particular speech task" than the total amount of air present in lungs. Both static and dynamic volume changes of lungs can be measured through the use of Spirometers and Plethsmograph.

These aerodynamic and acoustic parameters can be measured using the following instrument. The respirometry can be used as the simplest means of measuring air volumes (Beckett, 1971). 'Spirate' means 'Breathe'. Spirometry is measurement of various (dynamic) volumes of air breathed in and out. Many types of Spirometers are in use.

INSTRUMENTS USED FOR AIR VOLUME MEASUREMENTS

Wet Spirometers

Respiratory volumes and capacities are measured with a "Wet Spirometer". This instrument has a tube connected to a container that is open at the bottom. The tube goes right through the container. The open-bottom container is situated with another container filled with water. When the individual breath into the tube, the water is displaced and the amount of displacement is measured.

It consists of an air collecting “bell” inverted in a vessel of water. At the start of the test, water fills the bell, but air from the patient channeled proportional to the amount of air in it, and the water is displaced. This causes the bell to float; so that its height is directly proportional to the amount of air in it. A pointer linked to the bell indicates the volume of air.

Most Spirometers have a pen, moved by bell via a pulley arrangement that marks the moving chart to produce a permanent record of volume events. It is quite acceptable in the measurements of phonation volume or total speech volume (Beckett, 1971). The Spirometer is the classic instrument for assessment of gross respiratory volumes.

Dry Spirometers

Hand- held, or dry, Spirometers are compact and portable devices that do not depend on the displacement of water from a bell. There are 2 kinds: One is purely mechanical Here a small turbine within its case is driven by the air blown into the mouth piece its rotation moves a pointer around a dial on the outside of the case. Air volume is read from the position of the end of the task. The other kind of portable Spirometers is actually a flow transducer and integrator circuit system. A digital readout volume.

Compact Spirometers are useful only for gross assessments of air volumes, such as vital capacity. The mean air flow rates over the course of speech sound production/ phonation/ utterance are the values when assessing the general characteristics of speech and vocal function. This is usually measured using simple Spirometers. Articulatory volume can be determined. Spida, Spirotrac are examples of dry type Spirometers.

The parameter most important in Spirometers is forced vital capacity is defined as the maximum amount of air that can be exhaled after maximum inhalation. Vital capacity is commonly measured with a Spirometer and is generally reported in milliliters (ml) or liters (L). VC is measured as a basic indicator of respiratory ability and indicates that amount of air available for phonation.

Most clinical and research data reporting airflow parameters have been collected from conventional Respirometers or Pnemotochographic- pressure transducer systems, which are both expensive and non portable. Many clinical settings are not equipped with such instrumentation because of limited funds. Simple and inexpensive aerodynamic measuring devices are required in a variety of clinical settings for screening, diagnosing and validating the therapeutic progress. Rau and Beckett (1984) have adapted the light-weight, compact Spirometers to perform aerodynamic assessment of vocal function in adults. The validity of vital capacity and phonation quotient measurements made with such instruments were assessed and a multiple regression analysis was performed in order to develop a formula for estimating mean air flow rate from the phonation quotient i.e they have used Y=A (a constant) = BX to derive the statistical equation to estimate mean airflow rate. Spirometry is pivotal in screening, diagnosing and monitoring respiratory disease and is increasingly advocated for use in primary care practice.

Chest wall measurements

In speaking situations, respiratory kinematic analysis is used in which Lung volumes are estimated from the changes in ribcage and abdominal size and movement. Devices for transducing size changes include Magnetometers (Mead & Peterson, 1967), Mercury Strain gauges and Inductive Plethysmographs (Sackner et al, 1980).

The chest walls two parts contribute independently to the total lung volume change & the contributions need not be in the same direction. It is entirely possible for the ribcage to be enlarged (inspiring) while the abdominal wall is forcing the diaphragm upward (expiring). Therefore derivation of a lung volume estimate requires that the separate motions of ribcage & abdomen be added.

Magnetometer

It is composed of two coils of wire. An electric current is passed through one coil and generates an electromagnetic field. The strength of voltage induced by the electromagnetic field depends on the distance separating the coils. If one coil is placed on a person’s back and the other directly opposite on a point along his or her thorax or abdomen can be calculated in relation to the changing strength of the current. Measurements generated with this type of kinematic analysis typically include lung, RC, & abdominal volume initiations and terminations at the beginning and end of an utterance. The volume of air expended equals the initiation and end of an utterance.

SOME DISEASES AND DISORDERS IN WHICH PARAMETERS OF THE RESPIRATORY SYSTEM MAY BE AFFECTED

Condition	Respiratory Parameters
⇒ **Parkinson’s disease**	- Changes in chest- well shape, reduced rib cage movement and increased displacement of abdomen
	- Reduced VC
⇒ **Cerebellar disease**	- Reduced VC
	- Abrupt changes in motions of the chest wall

- Utterances initiated below normal lung volumes

⇒ **Cervical Spinal cord injury**

- Reduced VC, IRV and ERV
- Larger than normal lung volumes at beginning and ending of speech exhalation
- Larger abdominal volumes than normal
- Fewer than normal syllables per breath

⇒ **Cerebral Palsy**

- Reduced VC
- Difficulty accessing IRV and ERV
- Weakness and deformities of chest wall
- Abnormally high airflows during speech
-

⇒ **Mechanical Ventilation**

- Excessively high Tidal volume

⇒ **Voice Problems**

- Clavicular breathing
- Higher lung volume initiation and lower lung volume termination for speech

⇒ **Hearing Problems**

- Exhaling for speech at low lung volumes
- Excessive air expenditure per syllable

STUDIES ON SPIROMETRIC MEASURES IN NORMAL POPULATION

Mengesha and Mekonnen (1985) studied on Ethiopians for measurements such as Forced vital capacity (FVC), FEV1, FEV1/FVC ratio (FEV1%), forced expiratory flow (FEF 200-1200), and peak expiratory flow rate (PEFR). The results show that FVC, FEV1, and PEFR give significant regressions with age and height in both sexes. These indices have significant regression coefficients with percentage body fat, weight, and fat free mass (FFM) expressed independently of height in the men; only PEFR is significantly regressed on weight and FFM in the women. FVC and FEV1 in Ethiopians are found to be lower than in Caucasians and higher than in other Africans, Chinese, and Indians.

Williams, Miller and Taylor (1978) examined forced vital capacity (FVC) was recorded from three satisfactory efforts, and the FVC, one second forced expiratory volume (FEV1), and maximal mid expiratory flow (MMF, or FEF25-75%) on 599 men. The FVC and FEV1 in men were found to be similar to those of a group of emigrant Pakistanis and a north-western Indian population (Delhi) but higher than populations in south and eastern India. Pakistani women had values similar to those of women in northern India. While the FVC and FEV1 values did not differ between smokers and non-smokers, there was a significant difference in MMF (FEF25-75%) in the two groups. This latter finding corroborates studies on North American populations in which smokers generally have had higher lifelong cigarette consumption. This confirms the MMF (FEF25-

75%) to be a more sensitive test of subtle, asymptomatic changes in pulmonary function than the more widely used FVC and FEV1.

Previous studies have indicated that lung volumes in healthy, normal Pakistani adults are smaller than measurements reported in comparable healthy European populations; in order to confirm these findings and to examine the relationship of maximal expiratory flow rates to lung volumes, Ayub, Zaidi and Burki (1987) examined 250 non-smoking healthy subjects (116 men and 114 women) between the ages of 18 and 65 years. The results indicate that the forced vital capacity (FVC) and forced expired volume in 1 second (FEV1) were lower in the Pakistani population compared to European populations and North American populations of European descent. These data are in conformity with previous studies; however, in Pakistani men the effects of age on FVC and FEV1 were slight so that, after the fourth decade, the FVC and FEV1 values are very comparable between the European and Pakistani populations. Amongst Pakistani women, on the other hand, FVC and FEV1 remained lower than in their European counterparts throughout adult life. Maximal expiratory flow rates amongst the men did not correlate with age, and these values were very similar to those reported in age-matched European populations. In women, however, there was a significant correlation of maximal flow rates with age and height, and the maximal expiratory flows were decreased compared to European populations. These data indicate that in Pakistani men pulmonary mechanics may be different to their European counterparts, allowing for higher maximal expiratory flows at any given lung volume.

Crapo et al (1988) examined 300 healthy, lifetime nonsmoking American Indians for Spirometric functions. However, statistical comparisons, using an analysis of covariance, with data from a previous study of white persons showed the forced vital capacity and forced expiratory volume in 1 second equations for Indian men to be different from the equations for white persons. No statistically significant differences were found between the prediction equations for Indian and white women.

Chatterjee, Saha and Chatterjee (1988) examined pulmonary function measurements in 104 healthy non-smoking men from Calcutta with an age range of 20-59 years. Except for peak expiratory flow rate (PEFR), all the measurements were made with the help of two 9L closed-circuit type Expirographs using standard Spirometric techniques. PEFR was recorded by two Wright peak flow meters. Prediction formulae were derived on the basis of age and height for all the ventilatory tests except for FEV1%, FET and PEFR. These were predicted from age only. The prediction equation for VC, FVC, FEV1, FEV1%, MVVF and PEFR were reliable, but those for forced expitatory flows were not. The FVC and FEV1 values of the subjects, standardized for age and height, were much lower than those of Americans, Caucasians, Europeans and Canadians but similar to those of Pakistani healthy adults. On comparison from other parts of our country, it was revealed that the VC and FEV1 values of this study, after adjustment of age and height, were much higher than those of southern Indians but comparable with those of north-western Indians.

On the same lines to the previous study, Chatterjee and Saha (1993) investigated pulmonary function measurements in 230 healthy non-smoking women from Calcutta with an age range of 20-59 years. Age and height were found to be the significant predictor variables for VC, FVC and FEV1, while only age was significant for FEV1%. The FVC and FEV1 values of the subjects, standardized for age and height, were much lower than those of Americans, Europeans and Jordanians. Similar findings were reported for both men and women.

Crapo et al (1990) examined FVC, FEV1, FEV1/FVC, and FEF25-75% in 259 (116 men and 143 women) healthy nonsmoking Hispanic American volunteers from Utah and California. Linear regression equations were created for women greater than or equal to age 20 years and men greater than or equal to age 25 years using height, age, and weight as independent variables and the Spirometric indices as dependent variables. Weight was a significant predictor only for female FEV1. No differences were found for any of the age and height coefficients. The only differences found were in the comparisons of the equation intercepts (bias) for male FVC and FEV1 between data for the Salt Lake City white subjects and both Hispanic American and North American Indian men.

Humerfelt et al (1998) examined the effects from subjects for forced expiratory volume in 1 second (FEV1) and forced vital capacity (FVC) in 4989 asymptomatic never-smoking men. All eligible men aged 30-46 years living in western Norway (n = 45,380) were self-administered with a questionnaire. Three successful FEV1 and FVC recordings were obtained in 26,368 attendants using three dry-wedge bellow Spirometers operated by 10 different technicians. Within-subject standard deviation (SD) from three recordings of FEV1 and FVC was on average 102 and 106 ml, respectively, and increased with height (14 and 17 ml, respectively, per 10 cm) and body mass index (BMI) (11 and 14 ml, respectively, per 5 kg m-2). Between-subject SD of the mean of three FEV1 and FVC recordings was 591 and 754 ml, respectively, and increased in groups of increasing height (43 and 40 ml, respectively, per 10 cm). Small, but significant, differences were observed between technicians in within-subject Standard deviation and in levels of FEV1 and FVC. In conclusion, within-subject variability in three successful Spirometric recordings was small, but dependent on height and BMI of the subjects as well as technician performance. Novel multiple linear regression equations for FEV1/height2 and FVC/height2 were developed to be used in evaluating the effects from occupational airborne exposures in Nordic men aged 30-46 years.

Pulmonary functions are used for diagnosis, assessment and clinical management of breathlessness, and, as epidemiological and research tools. In

India the wide range of geographical and climatic conditions is associated with regional differences in lung functions. Most of the studies have restricted themselves to specific regions/ethnicities and a relatively short age span of 15-40 yr. Virani, Shah and Celly (2001) studied the pulmonary functions of the inmates (17-70 yr and of different ethnicities) of Sri Aurobindo Ashram, Pondicherry. A total of 397 non-smoking, healthy individuals aged 17 to 70 yr (195 men, 202 women) were investigated. The parameters measured included forced vital capacity (FVC), forced expiratory volume in 1 sec (FEV1, FEV1%), peak expiratory flow rate (PEF) and mean expiratory flow rate (MEF). The standing height and weight were also recorded. In both men and women, age showed significant negative correlations with all Spirometric functions, the height showed significant positive correlations with all pulmonary function test (PFT) parameters except FEV1 per cent while the weight did not show any significant correlation with any of the parameters except PEF. Men had significantly ($P < 0.001$) higher values than those of women for all parameters except FEV1 per cent. Prediction equations for all PFT parameters based on the age and height were derived for men and women. The ventilatory norms of both men and women based on age and height appear reliable for the FVC and FEV1. They can therefore be used to derive the normal values for healthy, non-smoking Indian adults between 17 and 70 yr. The coefficient for age obtained from the regression equations for FVC were found to be consistently smaller than those of others indicating that in the Ashram environment, age seems to have a lesser negative influence on pulmonary functions.

Fulambarker et al (2004) established reference values for pulmonary function in the Asian-Indian population living in the United States. Spirometry was performed on four hundred sixty subjects with measurements of FEV (1), FVC, and forced expiratory flow between 25% and 75% of vital capacity (FEF (25-75)). Lung volumes were measured in eighty subjects. Spirometric values derived from prediction equations, when compared to the values for whites from the selected studies in the literature, showed FVC to be 20 to 24% lower in men and 25 to 28% lower in women. FEV1 was 16 to 23% lower in men and 20 to 26% lower in women. Differences were not quite as large when compared to values from African Americans and other studies on Asians. They provided reference values for pulmonary function in nonsmoking Asian Indians living in the United States.

Ali Baig and Qureshi (2007) estimated normal values of peak expiratory flow rate (PEFR), forced expiratory volume in first second (FEV1), forced vital capacity (FVC) and ratio between FEV1/FVC among non-smoking staff and students at The Aga Khan University (AKU) Hospital, Karachi and studied the effect of age, gender and body mass index (BMI) on these variables .The mean values of FVC, FEV1, FEV1/FVC% and PEFR among males and females in different ages were compared by 't' test. Mean FVC, FEV1 and PEFR were found to be higher in males than the females in all the age groups, the difference in FVC was significantly higher in the age groups of less than 20 years and 20-29 years and respectively. The above Spirometric values declined with age and increased with height. Increase in age by one year resulted in 0.051 Liters decline in FVC whereas increase in height by a centimeter improved the FVC by 0.044L .The mean FVC, FEV1 and PEFR were higher in males in each age group. Females had higher FEV1/FVC%. Height had positive linear relationship and age was inversely related whereas BMI was not significantly associated with these variables.

Mohamed et al (2002) studied the effect of body weight components [bone-free lean body mass (BF-LBM), bone mineral content (BMC), and fat mass (FM)] measured by dual x-ray absorptiometry (DXA) on the lung-function variables (FVC, FEV1, and PEF) and to derive prediction equations for these variables in healthy adult Italians. Dynamic Spirometric tests and body composition analysis by DXA were performed on 58 nonsmoking males, mean age 26.72 +/- 1.98 years and BMI 25.51 +/- 0.64 kg/m2, and 60 nonsmoking females matched for age and BMI (29.61 +/- 1.65 years and 26.45 +/- 1.05 kg/m2, respectively). Multiple linear regression analysis showed that sex, age, height, and BF-LBM*Height were significantly associated with FVC, FEV1, and PEF. The prediction equations developed for FVC, FEV1, and PEF on the basis of the independent variables i.e. sex, age (y), height (m), and BF-LBM*Height (kg. m) had a significantly higher cumulative correlation coefficient compared with those based on age and height only. This report suggests that the BF-LBM, expressed independently from height, can be considered for predicting lung-function variables.

Chhabra (2009) studied Spirometric functions in 1672 male patients, aged 15 years. He found that FVC (North) and FVC (East) were close and greater than FVC (West) and FVC (South), which were in turn, close to each other. Up to the age of 40 years, the FVC (North) exceeded FVC (East), FVC (West) and FVC (South) by 2.4%, 11.8% and 13.3%, respectively, while in the above 40 years age group, it exceeded FVC (East) and FVC (West) by 5.1% and 9.67%, respectively. The differences, however, decreased substantially with increasing FVCs and even reversed at higher values with FVC (East) tending to exceed FVC (North) in both the age groups, and FVC(West) tending to exceed FVC (North) in the above 40 years age group. While northern and eastern, and, western and southern equations gave acceptable differences (less than 5%) in interpretation of abnormality in Spirometric data in patients up to 40 years of age, differences between other pairs of equations in this age group, and between all pairs in the above 40 years age group were large and unacceptable. Substantial variations exist in vital capacity predicted from various regional equations in adult males in India. In general, northern and eastern equations, and, western and southern equations yield closer values. While the northern Indian equation gives the highest predicted vital capacity, this is true only for lower values of vital capacities and at higher values, this may be less than that predicted from eastern or western equations. The regional differences may result in unacceptable errors in interpretation of Spirometry data, if inappropriate prediction equations are used.

Indian studies on Respiratory Measures

Verma et al, (1983) have developed a regression equation for indirect examination of ventilatory norms in terms of physical characteristics. Jain and Ramaiah (1969) have estimated lung function tests from age, weight, height and body surface area for men and women in the age range of 15 to 40 years. Similar regression equations were also established for men and women in the age range of 40-65years (Jain and Gupta, 1967). For boys of the age ranging from 7 to 14years, the ventilatory 'norms' were also estimated using age, height and body weight as predictors (Jain and Ramaiah, 1968). Verma et al (1983) have developed regression equations for indirect assessment of some ventilatory 'norms'(via: vital capacity, forced vital capacity, forced expiratory volume for one second, expiratory reserve volume, inspiratory capacity and maximum voluntary ventilation) for a wide range of 21-69 years in healthy Indian males. These studies have been compared with western norms. It has been reported that the mean vital capacity values in Indians were significantly lower than the western subjects (Bhattacharya, 1963).

The low vital capacity, generally obtainable in South India, is not due to race or nationality but to the warm climate, less tendency for exercise, low metabolism and poor chest expansion (Krishnan and Vareed, 1932). Nag, Chatterjee and Dey (1982) have assessed the effect of cigarette smoking on lung function in 108 smokers with matched group (105 non smokers) in the age range of 20-59 years. It is emphasized that lung function consistently decline with age and decline is further augmented by cigarette smoking.

Tests of ventilatory function are increasingly used by the clinicians for assessment of patient with respiratory diseases. Normal range of value in older subjects is also of value to the clinician for diagnosing and treating the chest diseases. Research studies found that decrease in the vital capacity was definite in old age. The data of Schmidt, Dickman, Gardner, and Brough (1973) in subjects between 55-94years also show that forced vital capacity, forced expiratory volume and expiratory flow decline with age. Meenakshi (1983) also observed similar results in 60-80 year old ‘normal’ subjects.

Vital capacity can be predicted on height and weight and there is no significant difference between the vital capacities and mean flow rates for both males and females (Krishna Murthy, 1986). Sudhir Banu (1987) found significant differences in mean airflow rates in dysphonics. The vital capacity of normal and dysphonic male group presented 2850cc to 3450cc and 2700cc to 3600cc respectively and it ranged from 1650cc to 3000cc in normal females, and from 1500cc to 3000cc in females of the dysphonic group.

Therefore, the literature on research studies in respiratory measures indicate that measures like FVC, FEV1, FEV1/FVC (%) are more extensively studied and these are measured using mainly wet and dry Spirometers. The data is also available from population from different geographical locations of the world.

CHAPTER III

METHOD

In the present study an attempt was made to obtain the normative values for forced vital capacity and slow vital capacity. 120 healthy adults in the age range of 20-40years who were natives of south India (Dravidians) were selected for the study. Subjects were sub divided into two groups i.e 20-30years and 30-40years. Each group comprised of 30 males and females.

The subjects were selected based on the following criteria

1. Should be of Dravidian origin
2. Should be free from any history of respiratory, circulatory and neuromuscular diseases
3. Should be non-smokers and non- alcoholics (heavy)
4. There should be no history of any serious illness and syndromatic conditions
5. Should be free from any obesity related problems

The instrument used in the study was Spirometer Helios 501 (RMS) (Figure 2). Helios 501 is a portable handheld monitoring Spirometer.

Fig 2: Spirometer Helios 501 (RMS).

The following measures were deduced from the study:

- **FVC (Forced Vital Capacity):** This is the total amount of air that can forcibly be blown out after full inspiration, measured in liters.
- **FEV_1 (Forced Expiratory Volume in 1 Second)**: This is the amount of air that can be forcibly blow out in one second, measured in liters.
- **FEV_1 / FVC (FEV %)**: This is the ratio of FEV 1 to FVC. In healthy adults this should be approximately 75 - 80%. FEV1/FVC is the FEV1 expressed as a percentage of the FVC.
- **Slow Vital Capacity (SVC)**: Is the maximum volume of air which can be exhaled or inspired in a slow/steady maneuver in liters.

- **TV (Tidal Volume)**: During each respiratory cycle, a specific volume of air is drawn into and then expired out of the lungs. This volume is tidal volume.

Subject's height and weight were recorded before the testing. Body Mass Index needs to be calculated for ruling out obesity. For calculating body mass index the individual's body weight is divided by the square of their height using the following formula (WHO, '95, 2004).

$$\textbf{BMI} = \textbf{Weight (Kg)/Height}^{2}\ \textbf{(m}^{2}\textbf{)}$$

Following are the established values of BMI:

Body weight	**BMI**
Underweight	<18.50
Normal	18.50 - 24.99
Overweight	>25.00
Obese	≥30.00

Table 2: BMI classification adapted from WHO (1995) & WHO (2004).

The subjects were considered for the study only when the BMI score was within the normal range. Each subject is tested individually at a time and was instructed about the test procedures. The test begins with a model given by the researcher. Before starting the test, mouth tubes were cleaned and sterilized properly.

Procedure for obtaining FVC (Forced Vital Capacity)

The subject is instructed to begin with a relaxed breathing, then to take a deep breath in and to immediately blow air out as hard and fast as possible into the mouth piece until no more air can be exhaled and then the subject should take another deep breath back in, with the mouthpiece still in the mouth, until the lungs are full. Ask the subject to do this activity when on the start button is clicked. The same task is repeated thrice each in both sitting and standing postures for every subject. The best maneuver out of the 3 trials is selected by the instrument as well as through visual examination and was considered for further analysis. The red line graph appears and the first portion (rising line) indicates inhalation and the second portion (falling line) indicates exhalation (Figure 5). From the results obtained, the values for FVC, FEV1, and FVC/FEV1 are noted for both postures. The demonstration was shown in the Fig 3.

Fig 3: Shows demonstration of Spirometry

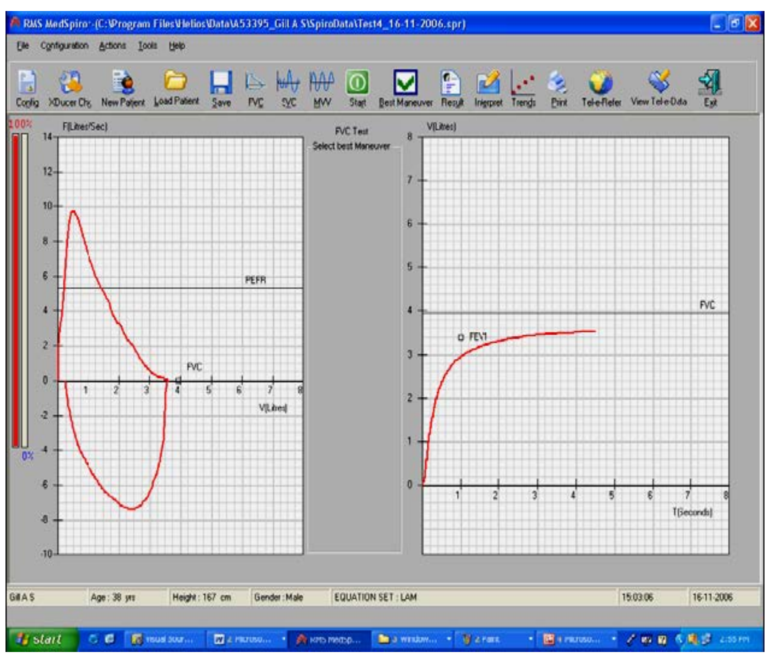


Fig 4: Shows the graph of forced vital capacity.

Procedure for obtaining SVC (Slow Vital Capacity)

The subject is instructed to begin with relaxed breathing through the mouth piece for two to three cycles and then to take a deep breath followed by a deep exhalation. Both inhalation and exhalation should be performed to the maximum extent but slowly and following this the subject should take a few gentle and normal breaths. The subject is asked to do this activity when the start button is clicked. From the results displayed on the screen, values for SVC and tidal volume were noted for further analysis.

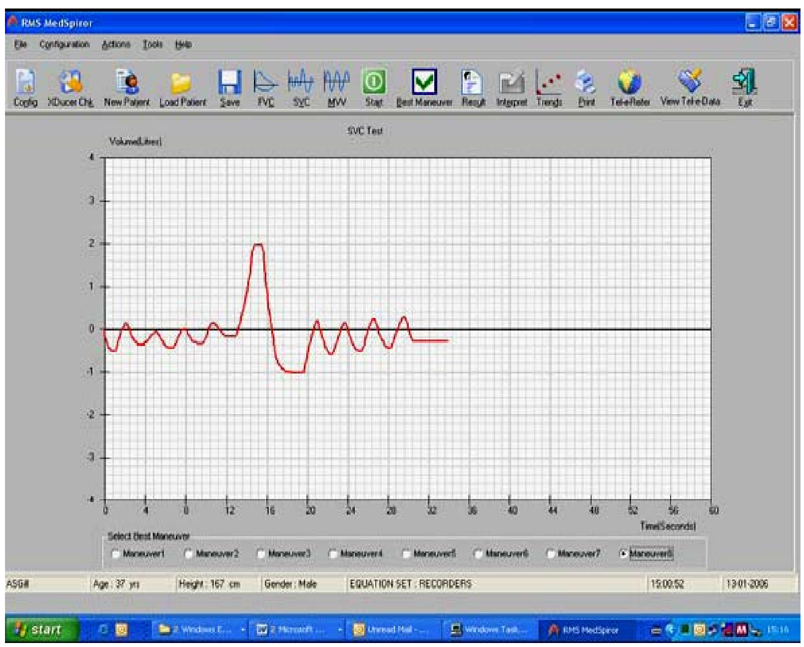


Fig 5: Shows the graph of the slow vital capacity.

Statistical procedures: Descriptive Statistics, Independent t test, Paired t test ANOVA, MANOVA and Post Hoc Test (SPSS Ver 16 & Ver 10) were used for statistical analysis.

CHAPTER IV

RESULTS AND DISCUSSION

The purpose of the present study was to develop normative values for the respiratory measures using a Spirometer. The parameters considered were forced vital capacity, slow vital capacity and some of their related parameters in sitting and standing postures. A total number of 120 healthy adult subjects in the age range of 20-40 years were studied. They were divided into 2 age groups ie 20-30 years and 30-40 years with 30 males and females in each group. Data obtained were analyzed using descriptive and inferential statistical procedures. SPSS (Ver 16 & Ver 10) were used for the statistical analysis. Using Descriptive statistics group means and standard deviations for each measure was obtained and are depicted in Tables 3 and 4.

Measures	Males							
	20-30 years				30-40 years			
	Sitting		Standing		Sitting		Standing	
	Mean(SD)	Range	Mean (SD)	Range	Mean(SD)	Range	Mean (SD)	Range
FVC	**3.71(.27)**	**2.85-4.07**	**3.78 (.33)**	**2.50-4.18**	**3.81(.27)**	**1.12-4.17**	**3.89(.28)**	**2.85-4.32**
FEV1	**3.39 (.38)**	**2.67-3.98**	**3.48 (.39)**	**2.69-4.05**	**3.78(.25)**	**2.85-4.04**	**3.85(.21)**	**3.20-4.12**
FEV1 / FVC (%)	**98.69 (1.98)**	**94.20-100**	**99.32 (1.27)**	**94.65-100**	**98.69 (2.10)**	**92.45-100**	**99.22 (1.35)**	**95.60-100**
SVC	**3.5(0.39)**	**2.68-4.37**	**3.61(.41)**	**2.77-4.55**	**3.75(.14)**	**3.46-3.98**	**3.82 (0.15)**	**3.50-4.11**
TV	**1.43(.61)**	**0.38-2.38**	**0.57(.56)**	**0.40-2.40**	**2.56(.63)**	**0.16-2.57**	**1.71 (0.56)**	**0.65-2.70**

Table 3: Shows the Mean & SD of the respiratory measures for males.

On observation of Table 3, it is evident that all the respiratory measures considered in this study were higher in the older age group of 30-40 years compared to the younger group of 20-30 years in men in both sitting and standing postures. The standard deviation was not much different in the two groups. The distribution of tidal volume was scattered compared to the other parameters in both the postures.

Measures	Females							
	20-30 years				30-40 years			
	Sitting		Standing		Sitting		Standing	
	Mean(SD)	Range	Mean(SD)	Range	Mean(SD)	Range	Mean(SD)	Range
FVC	**2.38(.37)**	**1.76-3.37**	**2.47(.35)**	**1.98-3.20**	**2.29(.16)**	**2.05-2.61**	**2.43(.21)**	**2.14-2.90**
FEV1	**2.26(.37)**	**1.76-3.22**	**2.41(.34)**	**1.98-3.31**	**2.67(.35)**	**1.86-3.22**	**2.76(.35)**	**1.98-3.31**
FEV1/ FVC (%)	**99.63 (1.02)**	**94.57-100**	**99.93 (.66)**	**96.35-100**	**99.69 (1.71)**	**94.57-100**	**99.87 (.66)**	**96.35-100**
SVC	**2.51(.41)**	**1.76-3.80**	**2.50(.59)**	**0.65-3.33**	**2.45(.24)**	**2.10-2.90**	**2.52(.23)**	**2.18-2.99**
TV	**0.99(.33)**	**0.70-1.85**	**1.12(.38)**	**0.12-2.00**	**0.64(.34)**	**0.70-1.27**	**0.77(.41)**	**0.12-2.00**

Table 4: Shows the Mean & SD of the respiratory measures for females.

In female subjects, considering the mean values, all the parameters had higher values in the younger group of subjects of 20-30years compared to the older group of 30-40 years in the sitting posture. However, in the standing posture, FEV1 and SVC were higher in the older group of women compared to the younger group. In general, the standard deviation of the respiratory measures was higher in females compared to their male counterparts. The normative values obtained in the two age groups of males and females are presented in Appendix 1.

Initially two way MANOVA was carried out to ensure the main effect of age, gender and interaction between age and gender within each measure in sitting and standing postures. Gender effect was significant in all the measures at 0.05 level of significance. Age was also significant in FEV1 in both postures at 0.05 level of significance. There was significant interaction between age and gender in SVC & TV in both postures. Since there is interaction between age and gender further analysis was carried out separately for age groups and gender.

Comparison across age

For comparison across age, Independent t test was used. Comparing males across the two age groups, it was found that FEV1 and SVC are significantly higher in the 30-40 years group compared to the 20-30 years group in both sitting and standing postures at 0.01 level of significance (Graphs 1 & 3).

Comparing females across the two age groups, it was found that FEV1 and TV are significantly higher in the 20-30 years group compared to the 30-40 years group in both the postures at 0.01 level of significance (Graphs 2 & 4).

As evident from the statistical analysis, there is no major difference between the two age groups for all the parameters considered in both males and females as there may not be significant changes in the chest volume over a span of just 10 years as considered in this study. Another possible reason is that FVC and FEV1 are relatively less sensitive than maximal mid expiratory flow (MMF) which is found to be a more sensitive test of subtle, asymptomatic changes in pulmonary function (Williams, Miller and Taylor , 1978). This finding is also in accordance to Ayub, Zaidi and Burki (1987), who reported that in Pakistani men and women, effects of age on FVC and FEV1 were found to be minimal and they state that only after the 4^{th} decade significant changes are expected. In the present study all the subjects were with in 40 years of age.

Comparison across gender

Using independent t test, it was found that all the measures were significantly higher in males compared to females in both the age groups of 20-30 years and 30-40 years at 0.01 level of significance. This finding is supported by Ali Baig and Qureshi (2007) who reported that mean FVC and FEV1 were found to be higher in males than in the females at all ages.

Comparison across standing and sitting postures

Using paired t test, in males it was found that all the measures were significantly different across sitting and standing postures in both the age groups at 0.01 level of significance (Table 5). Only tidal volume was found to be significantly higher in the sitting posture all the other measures were higher in the standing posture.

Measures	Males	
	20-30 years (N=30)	30-40 years (N=30)
	Sitting Vs Standing	Sitting Vs Standing
	"t" value	"t" value
FVC	3.56 *	9.14 *
FEV1	4.31 *	6.04 *
(%)	2.89 *	3.18 *
SVC	4.16 *	9.08 *
TV	3.49 *	5.79 *

Table 5: Shows the comparison of measures in sitting Vs standing posture in males.
*** indicates significant difference p<0.01**

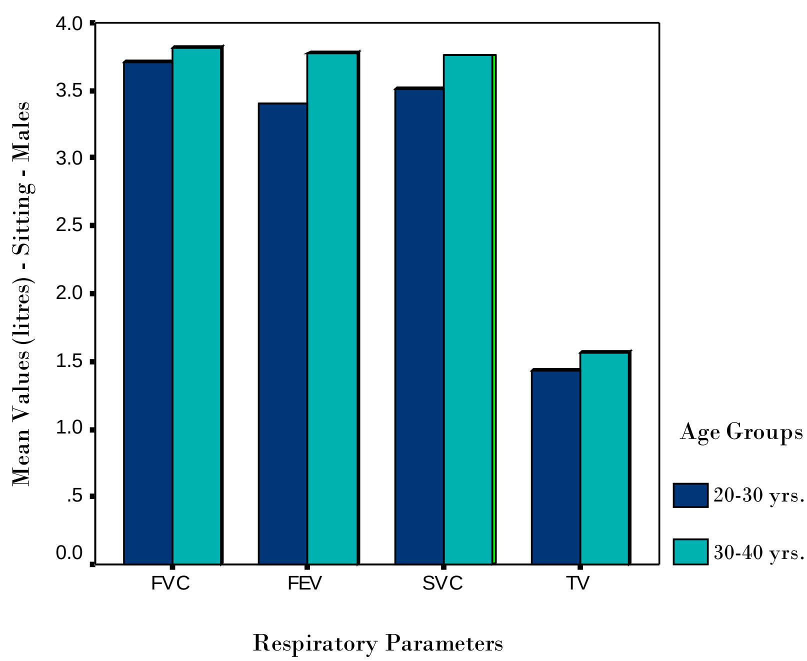
On the same lines, using paired t test, it was found that all the measures except FEV1/FVC were significantly higher in standing than in sitting posture among females in the 30-40 years group at 0.01 level of significance. Similarly it was found that all the measures except FEV1/FVC and SVC were significantly higher in the standing posture than in sitting posture for females in the 20-30 years group at 0.01 level of significance (Graphs 2 & 4). The t values obtained are shown in Table 6.

Measures	Females	
	20-30 years (N=30)	30-40 years (N=30)
	Sitting Vs Standing	Sitting Vs Standing
	"t" value	"t" value
FVC	2.64 *	5.67 *
FEV1	4.70 *	9.42 *
FEV1/FVC (FEV%)	-	-
SVC	-	8.00 *
TV	2.83 *	2.59 *

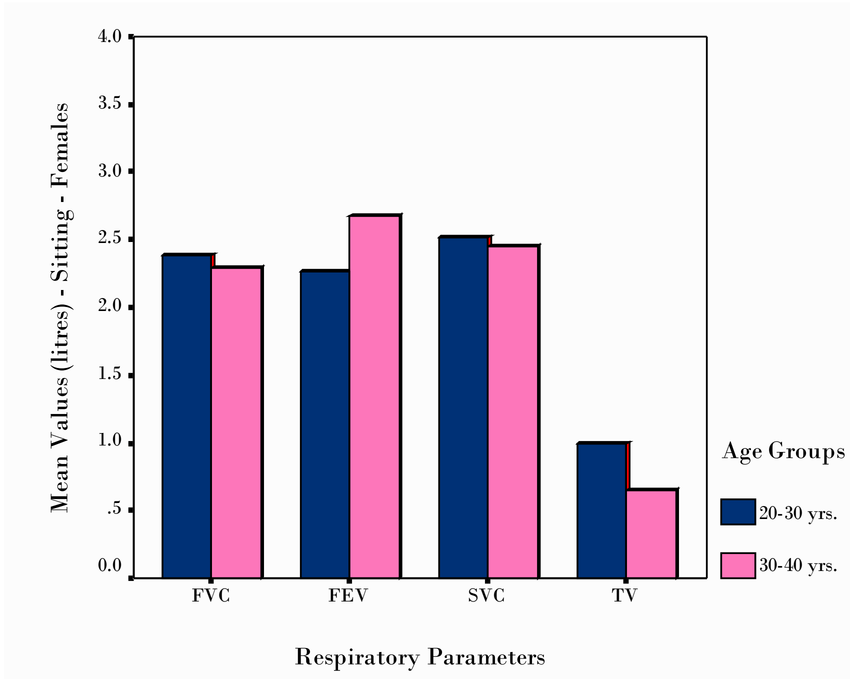
Table 6: Shows the comparison of measures in sitting Vs standing posture in females.

*** indicates significantly higher in standing posture (p<0.01).**

Hence, in both males and females most of the respiratory measures were significantly higher in standing posture than in sitting posture. This can be explained on the basis that the subjects take slightly larger inspirations in this posture than in the sitting position (Townsend, 1984). This finding is supported by Hixon, Goldman and Mead (1973) who investigated the effects of various body positions on respiratory behavior during oral reading. They found lung capacities are maximum in the upright position compared to other postures. In the upright position, gravity acts in an expiratory direction on the ribcage and in an inspiratory direction on the abdomen. The effect is mainly on the abdomen, being greater at low than at high lung volumes because the height of the abdomen is greater and its walls less stiff in the standing posture (Agostoni and Mead, 1964).

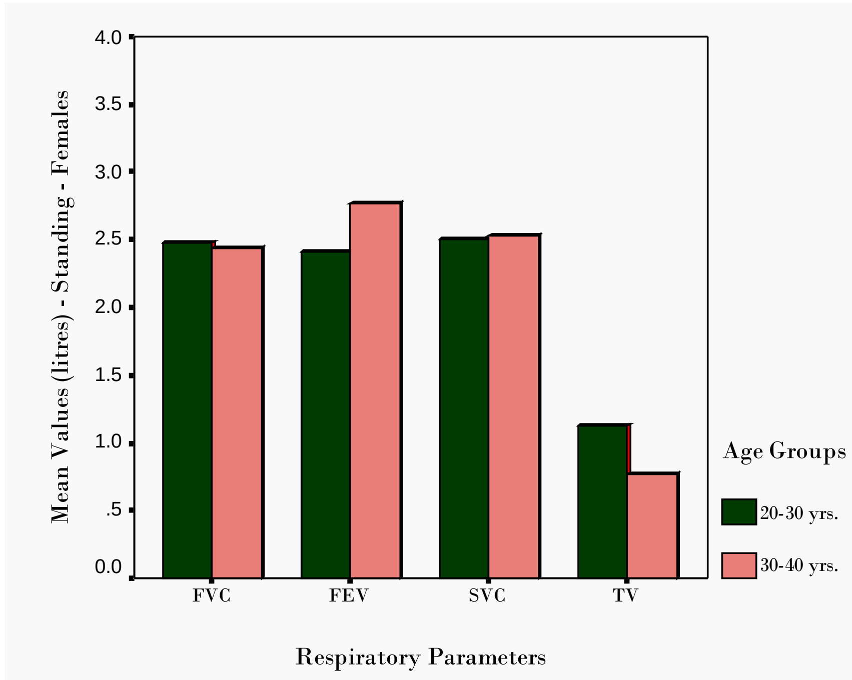


Graph 1: Shows mean values for males across age group in sitting position.



Graph 2: Shows mean values for females across age group in sitting position.

Graph 3: Shows mean values for males across age group in standing position.



Graph 4: Shows mean values for females across age group in standing position.

As observed in the present study, Lalloo, Becklake and Goldsmith (1991) found that on average all the Spirometric indices examined, except the peak expiratory flow rate (PEFR), were higher in the standing position compared to the sitting position although the change was only significant at the 5% level for FEV1 in women. Also, Townsend (1984) reported that the forced expiratory volumes in one and in six seconds and forced vital capacity were significantly larger in the standing than in the sitting posture.

Some of the literature reports on respiratory measures are predicted on height and weight. Hence, looking at the data obtained in the present study, it was felt that normative values could be determined for the respiratory measures considered in this study based on height, weight and body mass index measures.

And as the results indicated that most of the respiratory measures obtained in the standing posture are significantly higher than in the sitting posture, for comparisons based on height, weight and BMI, sitting posture measurements are not considered and only standing posture measures were considered.

Height: Based on height, 120 subjects in the study were grouped into 3 groups, ie 150-160cms (Group 1), 160-170 cms (Group 2) and 170-180 cms (Group 3). Groups 1, 2 and 3 consisted of 24, 32 and 64 subjects respectively including both males and females. Among the 3 groups, the range of height varied between 153 to 182 cms. The mean and standard deviation for the parameters with respect to height are presented in Table 7. As the 3 groups based on height did not have equal representation or rather unequal distribution of males and females, post hoc test was used to determine the significant difference in the respiratory measures across groups as a whole. And therefore gender difference was not considered based on height.

Measures	150-160cms (N=24)	160-170cms (N=32)	170-180cms (N=64)
	Mean (SD)	Mean (SD)	Mean (SD)
FVC	2.43 (0.27)	2.49 (0.31)	3.74* (0.48)
FEV1	2.47 (0.39)	2.67 (0.38)	3.60* (0.44)
FEV1/FVC (%)	99.98* (0.09)	99.95 (0.27)	99.26 (1.32)
SVC	2.44 (0.51)	2.53 (0.40)	3.66* (0.39)
TV	1.04 (0.44)	0.88 (0.41)	1.60* (0.59)

Table 7: Shows the Mean and SD of the respiratory measures based on height.
*** Indicates that measures are significantly higher compared to the other groups ($p<0.01$)**

Post Hoc analysis was used to determine the significant difference for the respiratory measures across the 3 groups. It was found that all the measures except FEV1/FVC were significantly higher in the 170-180 cms group (Group 3) compared to the other two groups. And FEV1/FVC was found to be significantly higher in 150-160 cms group (Group 1) compared to the other two groups. Groups 1 and 2 were combined as a single group (150-170 cms) as there was no significant difference for most of the parameters across these groups. So, two groups were made based on height. In general, the tallest group had significantly higher respiratory measures. Similarly Virani, Shah & Celly (2001) have reported that in both men and women height showed significant correlations in all the measures except FEV1.

Weight: Based on weight, the subjects were grouped into 5 groups ie <50kgs (Group 1), 50-60kgs (Group 2), 60-70kgs (Group 3), 70-80kgs (Group 4), 80-90kgs (Group 5). The Mean and Standard deviation are shown in Table 8. Groups 1, 2, 3, 4 and 5 consisted of 8, 37, 21, 49 and 5 subjects respectively. Among the 5 Groups, the weight range varied between 45kgs- 83kgs.

Measures	< 50kgs (N=8)	50-60kgs (N=37)	60-70kgs (N=21)	70-80kgs (N=49)	80-90kgs (N=5)
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
FVC	2.37 (0.25)	2.52 (0.43)	2.79 (0.61)	3.81 (0.37)	3.91 (0.15)
FEV1	2.37 (0.35)	2.71 (0.46)	2.70 (0.45)	3.67 (0.38)	3.80 (0.23)
FEV1/FVC (%)	1.00 (.00)	99.94 (0.26)	99.97 (0.10)	99.13 (1.44)	99.30 (1.06)
SVC	2.49 (0.79)	2.59 (0.48)	2.82 (0.66)	3.67 (0.38)	3.84 (0.21)
TV	1.11 (0.55)	0.92 (0.46)	1.14 (0.48)	1.67 (0.59)	1.33 (0.50)

Table 8: Shows the Mean and SD of the respiratory measures based on weight.

Using Mann-Whitney test, comparisons were made across the based on weight groups for obtaining the significant difference (Table 9). It was found that almost all the measures were significantly higher in Groups 4 and 5 compared to the other three groups. Therefore the first three groups were combined as a single group ie <50 – 70 Kgs and Groups 3 and 4 are combined as a single group i.e. 70-90 Kgs. Hence there are two groups based on weight for determining the normative values.

Weight	< 50kgs	50-60kgs	60-70kgs	70-80kgs	80-90kgs
< 50kgs	--	--	--	--	--
50-60kgs	NS	--	--	--	--
60-70kgs	NS	NS	--	--	--
70-80kgs	FVC, FEV1	FVC,FEV1, FEV1/FVC,SVC,TV	FVC,FEV1, FEV1/FVC,SVC,TV	--	--
80-90kgs	FVC, FEV1, SVC	FVC,FEV1, FEV1/FVC,SVC	FVC, FEV1, SVC	NS	--

Table 9: Shows the measures which are significantly different between the groups ($p<0.01$)
NS: Not significant.

As seen in height, subjects with more weight showed higher respiratory capacities. However, this observation needs to be viewed cautiously as all the subjects in the present study were with in normal limits of BMI. So it is erroneous to state that people with greater height and weight will always have higher respiratory capacities.

Body Mass Index: Based on body mass index, the subjects were grouped into 3 groups ie 18-20 (Group 1), 21-23 (Group 2) and 24-25 (Group 3). Groups 1, 2 and 3 consisted of 29, 61 and 30 subjects respectively. The normal range of body mass index varied between 18-25 (WHO, ’95, 2004) and therefore only those subjects within this range were considered for the study. Mean and standard deviation of BMI obtained are presented for each group in Table 10.

Measures	18-20 (N=29)	21-23 (N=61)	24-25 (N=30)
	Mean	Mean	Mean
FVC	2.52 (0.43)	3.23 (0.76)	3.57 (0.60)
FEV1	2.69* (0.47)	3.20 (0.66)	3.38 (0.62)
FEV1/FVC (%)	99.93 (0.29)	99.46 (1.16)	99.50 (1.16)
SVC	2.63* (0.58)	3.19 (0.70)	3.43 (0.64)
TV	0.9* (0.5)	1.32 (0.61)	1.54 (0.60)

Table 10: Shows the Mean and SD of the respiratory measures based on BMI.
*** Indicates that measures are significantly lower compared to the other two groups ($p<0.01$).**

Using Post Hoc analysis, it was found that all the measures except FVC and FEV1/FVC were significantly lower in 18-20 BMI (Group 1) compared to the other two groups (Table 10). Therefore Groups 2 and 3 are combined as a single group (BMI = 21-25) for determining the normative values.

Hence in the present study, an attempt was made to establish normative values based on height, weight and body mass index. The normative values obtained are listed in Tables 11 and 12.

Measures	Males				Females			
	150-170cms		170-180cms		150-170cms		170-180cms	
	<50-70kgs	70-90kgs	<50-70kgs (N=7)	70-90kgs (N=53)	<50-70kgs (N=56)	70-90kgs	<50-70kgs (N=3)	70-90kgs (1)
FVC	*		3.77	3.84	2.46	*	**	**
FEV1			3.36	3.71	2.57			
FEV1/FVC (%)			99.94	99.23	99.97			
SVC			3.78	3.71	2.49			
TV			1.67	1.65	0.93			

Table 11: Shows the Normative values based on height and weight for standing posture

*** Indicates no subjects were present in the group.**

**** Indicates less number of subjects in the group.**

Measures	Males		Females	
	18-20 (N=2)	21-25 (N=58)	18-20 (N=27)	21-25 (N=33)
	Mean	Mean	Mean	Mean
FVC	**	3.84	2.43	2.47
FEV1		3.67	2.60	2.55
FEV1/FVC (%)		99.29	99.94	99.88
SVC		3.71	2.54	2.49
TV		1.66	0.91	0.95

Table 12: Shows the normative values based on body mass index in standing posture.

**** Indicates less number of subjects in the group**

When the subjects were combined, the overall results have indicated that subjects with greater height and weight and BMI in the upper limit of the normative range (21-25) had higher respiratory capacities.

CHAPTER V

SUMMARY AND CONCLUSIONS

The purpose of the present study was to develop normative values for the most common respiratory measures using a Spirometer. The parameters considered were forced vital capacity, slow vital capacity and some of their related parameters in sitting and standing postures. A total number of 120 healthy adult subjects in the age range of 20-40 years were studied. They were divided into 2 age groups i.e. 20-30 years and 30-40 years with 30 males and females in each group.

Subjects were selected based on the criteria that they should be of Dravidian origin, should be free from any history of respiratory, circulatory and neuromuscular diseases, should be non-smokers and non- alcoholics, there should be no history of any serious illness and syndromatic conditions and should be free from any obesity related problems.

Subject's height and weight were recorded before the testing for calculating body mass index. The subjects were considered for the study only when their BMI score was within the normal limits.

Comparisons were made based on age, gender and postures. It is found that there is no significant difference between the two age groups for all the parameters considered in both males and females as there may not be significant changes in the chest volume over a span of just 10 years as considered in this study. Study also revealed that males had significantly higher respiratory measures than females in both age groups.

Comparison across postures indicated that respiratory measures are significantly higher in standing posture than in sitting posture because the subjects take slightly higher inspirations and because the height of the abdomen is greater and its walls are less stiff during standing. So standing posture is recommended for the respiratory measurements.

Out of the respiratory measures FVC, FEV1, FEV1/FVC (%), SVC and TV considered in the present study, it was found that FVC and FEV1 are more sensitive in indicating the significant differences across gender and posture. The normative values obtained in the study are provided in Appendix 1 which can be used clinically.

Research studies report that height, weight and body mass index are important variables in predicting the respiratory measures. Hence, normative values were determined for the respiratory measures considered in this study based on height, weight and body mass index. As the results indicated that most of the respiratory measures obtained in the standing posture are significantly higher than in the sitting posture, for comparisons based on height, weight and

BMI, sitting posture measurements are not considered and only standing posture measures were considered. The overall results indicated that subjects with greater height and weight and BMI in the upper limit of the normative range (21-25) had higher respiratory capacities.

The norms obtained based on categorizing subjects according to height, weight and BMI are also provided in the result section. However, these values cannot be recommended for clinical utility at present as there are less number of subjects with in those groups. Hence this only serves as a preliminary attempt to classify the subjects for their respiratory capacities based on these variables.

Future Directions

- The study can be replicated on larger population
- Pediatric and geriatric population can be studied on similar lines
- Norms can be established for other geographical regions in India

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APPENDIX - 1

Measures	Males		Females	
	Mean (SD)	Range	Mean (SD)	Range
FVC	3.83 (0.31)	2.50 - 4.32	2.45 (0.28)	1.98 - 2.90
FEV1	3.66 (0.36)	2.69 - 4.12	2.57 (0.39)	1.98 - 3.31
FEV%	99.31 (1.28)	94.65 - 100	99.91 (0.50)	96.35 - 100
SVC	3.71 (0.32)	2.77 - 4.11	2.51 (0.45)	0.65 - 2.99
TV	1.65 (0.57)	0.40 - 2.70	0.93 (0.45)	0.12 - 2.00

Norms for respiratory measures in Dravidian adults (20 – 40 years) for standing posture

Note: As the respiratory measures were not significantly different between the two age groups (20-30 Vs 30-40 years) the above norms are for Dravidian adults in the age range of 20-40 years.