THE MEASUREMENT OF MEAN AIRFLOW RATE IN NORMALS

REGISTER NO. 8405

Krishnamurthy B.N.

A Dissertation submitted as part fulfilment for M.sc., (Sp. & Hg)
to the University of Mysore.

Ail India Institute of Speech and Hearing
Mysore- 570 006

MAY 1986

To,
my teachers,
for the HEIGHT of their knowledge;
my parents,
for the WEIGHT of their love;
my friends,
far their "VITAL" CAPACITY to
accommodate me in their hearts.

CERTIFICATE

This it to certify that the Dissertation entitled THE MEASUREMENT OF MEAN AIRFLOW RATS IN NORMALS is the bonefide work done in part fulfilment for Final Year M.sc.,(Speech and Hearing) of the student with Register Number. 8405

Dr.M.Nithya Seelan
Director
All India Institute of
Speech and Hearing,
Mysore - 570 006.

CERTIFICATE

This is to certify that the Dissertation entitled THE MEASUREMENT OF MEAN AIRFLOW RATE IN NORMALS has been prepared under my supervision and guidance.

12/5/86

N.P.Nataraja
Reader and H.O.D.
Dept. of speech sciences
All India Institute of
Speech and Hearing
Mysore- 570 006.

DECLARATION

This Dissertation entitled: The Measurement of Mean Airflow Rate in Normals, is my own study done under the guidance of Mr.N.P.Nataraja, Reader and Head of the Department of Speech Sciences, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier at any University for any other Diploma or Degree.

Mysore.

Dated: Register No. 8405

ACKNOWLEDGEMENT

I am grateful to

My teacher and guide, Mr.N.P.Nataraja, Reader and Head of the Department of speech Sciences, without whose unceasing inspiration and constant interest, the dissertation in its present form could not havebeen achieved.

Dr.M.Nithya Seelan, Director, All India Institute of Speech and Hearing, Mysore for giving me this opportunity to work.

Mr.C.S.Venkatesh, Mr.C.D.Shanbal, Mr.Jagadish and Mr.K.R.Chandrashekar, for their help during data collection.

Mr.R.sridhara, Mr.Harpreet Singh for their help during analysis.

All my subjects for lending their invaluable time in the completion of my work.

All my classmates for their timely help at different stages of this work.

Ms.Rajalakshmi R Copal and Mr.R.Ramakrishna for finishing the work in short notice.

TABLE OF CONTENTS

Page No.

INTRODUCTION

Diagnostic procedures for voice disorder comprise teats that elicit information regarding the actual process of voice production and the nature of the sound generated. The purposes of the diagnostic procedures are: (i) To determine the cause of a voice disorder, (ii) To determine the degree and extent of the causative disease, (iii) To evaluate the degree of disturbance in phonatory function, (iv) To determine the prognosis of the voice disorder as well as that of the cause of the disorder, and (v)To establish a therapeutic programme.

Dysphonia occurs as a result of disordered respiratory and laryngeal function, these two functions being interdependent in the production of voice. The disturbance of function of the respiratory component is seen as an alteration in the efficiency of the activator to provide satisfactory air support for normal laryngeal action and is commonly accompanied by an associated organic laryngeal manifestation, speech therapy intervention to remedy the disorder of function in the use of voice can satisfactorily reverse the organic manifestation in moat voice disordered cases. So the measurement of airflow has gained importance in recent years. There are different ways of direct and indirect assessment, observation and/or measurement of the parameters of voice. Aerodynamic measurements deal with the aerodynamic factors. Much of the literature has indicated the importance of mean flow rate and maximum phonation time measurements in assessing laryngeal function. Mean airflow fata has been shown to be a reliable indicator of proper air usage during phonation (Yanagihara, Koike, and Von Leden, 1966). Mean airflow rate is also related to the regulation of pitch and intensity (Isshiki, 1965; Isshiki and Von Leden, 1964; Yanagihara and Koike, 1967).

Iwata and VonLeden (1970) have recommended the use of the phonation quotient (the ratio of vital capacity to phonation time) as an indicator of air usage When mean airflow rate cannot be directly measured. Hirano, Koike and VonLeden (1960) have reported a significant correlation between phonation quotient and mean air flow rate in normal adult subjects.

Therefore, the question of the suitability of simple and inexpensive aerodynamic measuring devices for determining the phonation quotient (permitting the estimation of mean airflow rate) was paramount to this study.

Most clinical and research data reporting airflow parameters have been collected from conventional respirometers or pneumotachographic - pressure transducer systems, which are both expensive and non-portable. Many clinical settings are not presently equipped with such instrumentation because of limited funds. In the absence of fully instrumented laboratory, vocal dysfunction is usually described interms of subjective and indicate sense impressions. Variable sense impressions are not easily translated into useful numerical data to measure function, rehabilitation progress, or for meaningful, specific transmission to medical specialists. Therefore it is necessary to assist the person who most evaluate vocal function without access to laboratory facilities.

The purpose of this study is to establish simple and inexpensive aerodynamic measuring device which may be used in a variety of clinical settings for screening, diagnosis and validation of therapeutic progress.

The purpose of the study was (a) to find out the possibilities of predicting vital capacity based on height and weight of an individual; and (b) to predict mean airflow rate based on the vital capacity (estimated) and maximum phonation duration and to validate the methods.

30 males (mean age of 21.47 years) and 30 females (mean age of 20.8 years) served as subjects for the part (a) of the study. Part (b) consisted of 15 males (mean age of 23.43 years) and 15 females (mean age of 19.67 years).

The vital capacity, height, and weight were measured for each subject. Based on height, weight, and vital capacity 'nomograms' were constructed. Then the phonation quotient, mean airflow rate obtained for each subject was compared with mean airflow rates estimated (mean airflow rate was estimated using the formula given by Ran and Beckett, 1984 i.e. MFR-77+.236 PQ). Based on height and weight the vital capacity was estimated in part (b) of the study. Then vital capacity and mean airflow rates were obtained from expirograph also. The estimated vital capacity, phonation quotient, and mean flow rates were compared with obtained vital capacity, phonation quotient, and mean flow rat* values. Then correlation coefficients were found out between the obtained and estimated values, which indicated high positive correlation between obtained and estimated measures.

Limitations:

i) the study included the age range of 17 to 98 years only.

ii) Frequency and intensity were net monitored during phonation measurement and mean airflow rate measurements.

Hypotheses:

i) There is a relationship between the vital capacity, and height and weight of an individual.

ii) There is a significant correlation between phonation quotient and mean airflow rates in normal adult subjects, and mean airflow rate can be calcalated using the phonation quotient values.

Null Hypotheses:

i) There is no significant difference between males and females interms of vital capacities.

ii) There is no significant difference between males and males interms of height and weight.

iii) There is no significant difference between males and females interms of maximum phonation durations.

iv) These is no significant difference between vital capacity (obtained and estimated) in males.

v) There is no significant difference between vital capacity (obtained and expected) is females.

vi) There is no significant difference between phonation quotients (obtained and estimated) in males.

vii) There is no significant difference between phonation quotient (obtained and estimated) in females.

viii) There is no correlation between phonetics quotient sad mean airflow rates in males.

ix) There is no correlation between PQ and MFRs in females.

x) There is no significant difference between MFR(obtained and estimated) in males.

xi) There is no significant difference between MFR (obtained and estimated) in females.

<u>Implications:</u> (i) This study has shown that it is possible to find out VC based on height and weight of an individual and hence ean be used to calculate PQ. Further the MFR can be calculated by using the formula given by Ran and Beckett (1984). Thus MFR can be used in screening, diagnosis, and to monitor therap eutic progress in case of dysphonics. It will be a simple inexpensive aerodynamic measuring device, (ii) The method ean be used to develop similar procedures for different age groups.

2.1

REVIEW OF LITERATURE

Every human society, no matter how primitive, has developed the ability to communicate through spoken and written language and this ability has frequently been cited as the single most important characteristic that sets human apart other animals (Curtis, 1978).

Speech is a form of language that consists of sounds by utilizing the flow of air expelled from lungs.

The simple definition of voice states that the voice is the "sound produced primarily by vibration of vocal folds". (Travis, 1957).

Several workers in the field have defined voice differently.

The definition offered by Judson and Weaver (1942) states that "the voice is the laryngeal vibration (phonation) plus resonance". And they call phonation as laryngeal vibration.

Fant (1960) defines voice using the formula P-S.T in which the speech sound P, is the product of the source S, and the transfer function of the vocal tract T.

Some definitions of voice restrict the term to the generation of sound at the level of the larynx, while others include the influence of vocal tract upon the generated tone, and still others broaden and definitionto include aspects of tone generation, resonance, articulation and prosody.

Michel and Wendahl (1971) define voice as "the laryngeal modulation of the pulmonic ait stream, which ia then further modified by the configuration of the vocal tract".

The normal voice should possess certain characteristics of pitch, loudness, and quality which will make the meaning clear, arouse proper emotional response to ensure a pleasant tonal effect upon the hearer (Berry and Eisonson, 1962).

It is apparent that a'good' voice is a distinct asset and a'poor'voice, may be an unfortunate handicap. If a person's voice is deficient enough in some way that it is not a reasonably adequate vehicle for communication or if it is districting to the listener. One can consider this as constituting a disorder.

In general, the following requirements can be set to consider a voice as adequate: (i) The voice must be appropriately loud, (ii) Pitch level must be appropriate. The pitch level must be considered in terms of age and sax of the individual. Men and women differ in vocal pitch level. (Children differ from adults in their use of vocal pitch level, i.e. with an age the pitch changes, (iii) Voice quality must be reasonably pleasant. This criterion implies the absence of such unpleasant qualities as hoarseness, breathiness, harshness, and excessive nasal quality, (v) Flexibility must be adequate. It involves the use of both pitch and loudness inflection. An adequate voice must have sufficient flexibility to express a range of differences in stress, emphasis and meaning. A voice which has good flexibility is expressive. Flexibility of pitch and flexibility of loudness are not separable, rather they tend to vary together to a considerable extent.

The above criteria are subjective as it is difficult to get agreement on such terms as 'adequate', 'appropriateness', and others. Nataraja and Jayaram (1982) propose a different criteria to judge the normality of ("good") voice - "The good voice is one which has optimum frequency as its fundamental (habitual) frequency". It has been shown that there will be maximum physio-acoustic economy at the level of the optimum pitch (Shashikala, 1979).

"In normal voice production the vocal organs are (1) the lungs and trachea, which act as a bellows and windpipe, (2) the larynx, a complex organ which forms the generator, and (3) the vocal cavities (vocal tract) which form the resonator system driven by the glottis – generator in the larynx. These organs make a unit, and it is not possible to understand the function of the unit without a knowledge of the properties of the components" (Van den Berg, 1958).

"The role of the larynx, the central voice organs, has upto now been widely discussed. In ancient times, Galen (130-AR) thought the trachea to be the central organ actingas a flute. Dodart proved in 1700 that the vocal originates in the larynx.

However, by analogy to mouth whistling, he thought that the pitch dependent upon the area of the glottis" (Van den Berg, 1950).

Ferrein (1741) from animal experiments, proved that the vibration of the vocal folds are essential and not of secondary nature.

Functionally, the larynx is a valve and a second generator. As a valve it regulates the flow of air into and out of the lungs and prevents the entry of food inte the lungs. The two functions are accompanied by a relatively complex arrangements of cartilages, muscles and other tissues.

How it is agreed that the glottis is the first major constrictor involved in the process of forming speech. Airflow passing through the glottis produces sounds when the vocal golds are properly adducted. During voicing the folds open and close, producing quasiperiodic airflow. It helps in producing different tonal qualities (Brackett, 1971), i.e. the breathing apparatus has been likened to a power supply for the sound -producing mechanism.

The essential function of the larynx has been widely accepted, but the controversy arised regarding the way the vocal cords are set into vibration. There are two main theories of phonation:

1) Myoelastic - aerodynamic theory.

2) Neurochronaxic theory.

These two theories of voice production have dominated much of the literature.

> "The myoelastic - aerodynamic theory postulates that the vocal folds are subject to well established aerodynamic principles The vocal folds are set into vibration by the air stream from the lungs and trachea, and the frequency of vibration is dependent upon their length in relation to their tension and mass. These factors are regulated primarily by the delicate interplay of the intrinsic laryngeal muscles. The myoelastic - aerodynamic theory was first advanced by Johannes Muller , 1843, and has enjoyed popular acceptance ever since. Minor modifications of the theory have been suggested by Tonndorff (1925) and by Smith (1954), but its salient features have remained unchanged through the years" (Zemlin, 1981).

More recent nearo-chronaxic theory (Husson, 1950) postulates that each new vibratory cycle is initiated by a nerve impulse transmitted from the recurrent branch of the vagus nerve* The frequency of vocal fold vibration is dependent upon the rate of impulses delivered to the laryngeal muscles. These theories cannot be united and models and analogs of the vocal tract, direct observations and photography of laryngeal functions in normals and abnormal laryngeas, anatomical and histological evidence, information from electromyographic recordings of laryngeal muscles, as well as physical and theoretical data helps to resolve the controversy between the myoelastic—aerodynamic and neurochronaxic theories of voice production. It has been shown that the myoelastlc-eerodynamic theory provides a straight forward explanation of most of the known phenomena of voice production, whereas there is not much experimental evidence in support of neurochronaxic theory and it is unable to explain a large number of phenomena (van den Berg, 1958). Thus it is widely accepted that the aerodynamics plays on important role in setting the vocal folds into vibration.

The three basic processes i.e. breathing, phonation, and resonance operate not as three functions but as inseparable aspects of one function. Amplification of sound wave would not occur if the vocal cords did not produce vibrations. The air supply or airflow is essential to set the vocal folds into vibration. Breathing, phonation, and resonance, therefore are inseparable phases of one function — vocalization or voice production.

> "The D.C. flow of air is converted into A.C. sound pulses, as during the production of sound the vocal cords are in the adducted position. In this position, they vibrate alternately, opening and closing the glottis for very short periods. Actually it is the air current from the lungs that separates the vocal folds and open the glottis. But as the air begins to stream out through the narrow glottis, a suction takes place which draws the vocal folds together again (the Bernoulli effect). Immediately, the subglottic pressure again forces the vocal folds apart, and the airstream out throughthe glottis. The vibratory movements are performed at a frequency, determined by, among other things, the tension of the vocal folds. Their vibratory frequency in tarn determine the frequency of the air puffs which are the primary source of the sound" (Fletcher, 1959).

Thus the "Vocal sound is produced by therapid, periodic opining and closing of the vocal cords that segment a steady expiratory airflow from the lungs into a series of air puffs or pulsations. The frequency of the vocal fold vibrations (separation - apposition cycles) corresponds to the fundamental frequency (pitch) of the laryngeal sound, which then generates higher harmonica (formants) as it passes through supralaryngeal resonatory cavities. Voice intensity (loudaess or volume) is largly dependent upon the development of proportionately higher levels of subglottic pressure. Fundamental frequency (pitch) is increased primarilyby increasing vocal cord tension and length, and secondarily, by increasing subglottal air pressure and elevating the larynx. In addition, the rate of sound production (energy per unit of time) is limited only by the lungs' capacity to produce air flew (volume per unit of time). Vocal sound production is therefore vitally dependent upon the forces of expiration for the smooth and steady maintenance of subglottic air pressures (Gould, 1971a, Gould, 1974; Gould and Okamura, 1973; 1974)" (Darby, 1981).

It is necessary to understand various aspects of pulmonary physiology described interms of different volumes.

"Air in the lung is devided into four primary volumes and four capacities (which overlap the volumes) that are altered in disease (Fig.l). The following four volumes and capacities are representational for a young adult male given by Comroe, Forster, Dubois, et al (1962).

1. The tidal volume (TU=600cc) is the air moved in or out under normal resting breathing conditions.

2. The inspiratory reserve volume (IRV = 3000cc) is the maximal amount of air that can be inspired from the end inspiratory position of quiet breathing.

3. The expiratoryreserve volume (IRV = 1200cc) is the maximal amount that can be expired from the end expiratory level.

4. The residual volume (RV =1200cc) is the amount which remains in the lung after maximal forced expiration.

The vital capacity (vc=4800cc) is the maximal amount which can be expelled after full inspiration. The total lung capacity

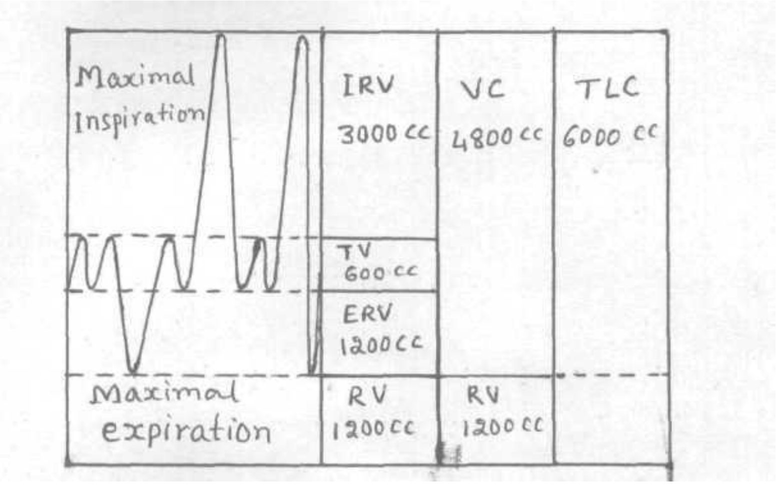
(TLC = 6000cc) is the amount of air in the lung after maximal inspiration. The timed vital capacity (TVC) measures the rate at which the vital capacity (VC) can be emptied from the lungs. For example, with forced expiration, 83% of the VC (about 4000 cc) can be exhaled in one second and 94% (about 4500 cc) within three seconds.

This measure of pulmonary function may also be termed the forced expiratory vital capacity (FEW) and subdivided into volumes per unit time. The forced expiratory volume in the first second exceeds the volume exhaled in the second second in a series of progressive volume reductions through the fifth (normal) to seventh (obstruction) seconds. The forced expiratory volume in the third second (FEV_3) exeeds the volume in the first second (FSV_1) because FEV_3 summates the air volume exhaled in the first, second, and third seconds.

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 (Hickam, 1963). The respiratory system has substantive reserve capacity, as the testing breathing rate is 12 breaths per minute, moving only 7200 cc of air per minute". (Darby, 1931).

The amount of air available for individual for the purpose of voice phonation depends upon the vital capacity of an individual.

Hirano (1982) states, while discussing the acrodynamic tests, "The aerodynamic aspects of phonation is characterized by four parameters: subglottal pressure, supraglottal pressure, glottal impedance and the volume velocity of the airflow at the glottis. The values of these parameters varies 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".



LUNG VOLUMES AND CAPACITIES

Representation of a Spirographic tracing of lung volumes. The sequence illustrates tidal volume, expiratory reserve volume, inspiratory reserve volume, and vital capacity. The vertical box diagram illustrates representational volumes and capacities for an young adult made.

IRV = Inspiratory reserve volume;
TV = Total volume;
ERV = Expiratory reserve volume;
RV = Residual volume;
VC = Vital capacity;
TEC = Total lung capacity.

(Reproduced from Darby, J.K., Jr., (Ed) "The interaction between Speech and Disease". In Speech Evaluation in Medicine, 1981 Grune and stratton, Inc, New York, 10003).

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, interms of flow rate, which in turn would show the status and functioning of laryngeal system.

The volume and force of the air stream determine the frequency, intensity, aad duration of phonation on one expiration. Thus it becomes important to study the total volume of air, the mean airflow rate and subglottal air pressure to understand the relationship between these factors and frequency, intensity of voice and duration for which phonation can be sustained.

The vocal pitch is related directly to the frequency of vocal fold vibration. The primary mechanism for increasing the pitch is to elongate the folds by contracting the cricothyroid muscle. (Sonninen, 1954; Hollien, 1960; Hollien and Moore, 1960; Damaste, et al., 1968; Faaborg-Andersen, 1957; Arnold, 1961; Yanagihara and Von Leden, 1966; Hirato et al., 1967; Gay et al., 1972).

The airflow is important in bringing about vocal fold vibrations. The subglottal aad transflottal air pressures forces the gently approximated vocal folds apart, setting tham into vibration, as explained earlier. Optimal phonation for speaking and singing requires continuous abduction - adduction of the vocal folds, with subtle changes in fold length and mass, and subglottal air pressure. The regulation of this airflow is basically involuntary and highly automatic in ordinary speech, but the public speaker or singer learns to rely heavily on a partial control of his or her breathing mechanism (Boone, 1983). The pressure below the vocal cords which builds up when the folds are closed, called subglottal pressure, provides an indication of cord closure as well as additional information about fundamental frequency of the voice.

The actual relationship between the subglottal air pressure and pitch is confusing because of the diversity in approaches. Although rises in pitch may be accompanied by increases in subglottal pressure, increases in subglottal pressure need not produce rises in pitch. Brodaitz (1959) for example, has noted that in singing an upward scale, the subglottic air pressure increases because the greater stiffness of the stretched vocal folds affers increased resistance.

In 1846, Liskovious noted that pitch was elevated as the glottic chink narrowed and subglottic pressure increased and with constant glottal opining, pitch rose in response to increased air pressure alone. Negus (1929) noted that in actual phonation, elastic tension and airpressure are associated in such a way that a alight increase in air pressure causes a considerable rise in pitch. Wullstein (1936) found that frequency rose from 85 to 125 cps when air pressure was doubled in freshly excised laryngea. Isshiki (1959) noted in electrical stimulation experiments on dogs that pitch was increased by increasing airflow alone and that pitch elevation was accompanied by increasing subglottic pressure if airflow remained constant. Ladefoged and McKinnay (1963) found "fairly good correlation between subglottal pressure and the logarithm of the frequency of vibration of the vocal cords". Timcke et al (1958), Von Laden (1961) and Van den Berg (1957) have demonstrated the effect of subglottic pressure oa pitch i.e. pitch increases with increased subglottal air pressure.

Pressman and Keleman (1955) state that the actual variation produced in tone by pressure changes is relatively small. An increase ia subglottic pressure, with laryngeal tension held constant, will produce a negligible (relatively small) rise in pitch. In addition, pitch changes are madiatedprimarily through modifications in glottic tension and mass.

Pitch lowering may be produced by a decrease in activity of muscles (i.e. decrease in tension) that are already contracting (Erickson and Atkinson, 1976).

"Intensity Changes play an important part in verbal behaviour. Ferrein (1741) examined glottal adjustments oa living dog larynges, and concluded that loudness of phonation is greatest when the glottis is narrowest. He also demonstrated that an increase in breath pressure tended to increase the amplitude of vocal-fold movement. Muller (Middle of 19th century) has concluded, from studies on cadaver, dog, and artificial laryngea, that vocal intensity, with a given pitch, was dependent upon the relationship between subglottal air pressure and vocal fold tension, "the latter varying inversly with the former". Merkel (1873) has reported that Changes in intensity are accompanied by a proper balance between the force of subglottal air end the tension of the glottic muscles. But there is a direct relationship between the quantity of air passing through the larynx and increased vocal intensity."

Aikin (1902) concluded from observations of the vocal folds in living humans that vocal intensity was higher when there was a small glottal opening. Franaworth(1940) and Pressman (1942) have noted that as intensity increased, the folds remained closed for a proportionately longer time during each vibratory cycle. Fletcher(1950) noted that the duration of the closed phase of the vibratary cycle increases with intensity. Variations in the loudness of phonation are related directly to changes in sub-glottal air pressure (von den Berg, 1956j Bouhuys, et al., 1966). In connected speech this is accomplished by changes in respiratory and/or laryngeal activity (Isshiki, 1964, 1965, 1969). Glottal resistance is dominant in varying loudness at low pitches (Isshiki, 1964) and at higher pitches, expiratory force seems to be the dominant factor.

The intensity of the voice is directory related to changes in subglottal and transglottal air pressures. Hixon and Abbs (1980) have written "Sound pressure level is governed mainly by the pressure supplied to the larynx by the respiratory pump". Therefore airflow is important in changing pitch, to some extent, and intensity.

McHenry ana Reich (1985) have the following openion about effective airway resistance and vocal sound pressure level in cheear-leaders with a history of dysphonic episodes. The control of vocal SPL is an extremely complex process involving the unconscious manipulation and interaction of numerous variables (Fant, 1982) sad often vary both within and between speakers. It is also viewed that SPL increase primarily as the result of heightened glottal resistance and exhalatory airflow (Isshiki, 1965, 1969). Habitual use of high SPL appears to be detrimental to vocal fold tissues in the absence of physiologically efficient SPL regulation. It can be speculated that if an individual phonatea at a high SPL using excessive or inappropriate laryngeal muscle effort, inefficient vocal fold body/cover relations, or an inadequate respiratory driving pressure, vocal fold irritation may result. Vigorous shouting and cheering may causa vascular engorgement, injury to muscles or laryngeal joints, or hematoma (Wilson, 1979). Individuals who habitually increase vocal SPL by markedly increasing laryngeal muscle effort without a substantial simultaneous increase in respiratory effort, presumably, are more likely to develop laryngeal pathology than those who concomitantly increase respiratory effort (Boone, 1977). Therefore effective use of respiratory mechanism is necessary in driving the generator better.

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; subglottal airpreasure immediately rises and remains at a relatively constant level through out phonation. The respiratory system maintains not only a constant subglottal airpreasure bat also a constant flow of air through the glottis. Aa air escapes, the lungs must decrease in size continuously ao that subglottal 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 (Bouhuya et al 1966; Mead et al 1968).

Therefore large lung volume, better airflow rate will help in getting voice for a longer duration.

Subglottic pressure is some what difficult to measure, since the measuring device must be located below the glottis in the trachea inorder to record the pressure built up when the vocal folds close. It ia 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 subglottal 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.

The normal speaker uses only a email amount of his total vital capacity for speaking, (Goldman and Mead (1973) have stated that the normal speaker uses only about twice the air volume for speech that he uses for a quiet, 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. Nadoleczny and Buchsinger (1934), concluded, after an experiment, that significantly larger vital capacity values were found in well trained athelets and professional singers. Hicks and Root (1965) 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 differences in vital capacities between trained and untrained singers.

Yanagihara and Koike (1967) have related vital capacity to phonation volume; while Hirano, Koike, and Von Laden (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 co-efficients ranging from 0.59 to 0.90. Hirano et al (1963) 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 duration* or longer vital capacities. Bouhuys et al (1968), reported singers designated as having "poor quality", to be having smaller vital capacities than singers categorised as having'good' or "average' quality.

The following table shows the vital capacity in adult males as quoted by various investigators:

Investigators		VC in cc
Murray and Lewis	-	3500
Gray and Wise	-	3700
Wise, McBurney and Mallory	-	3700
Tabor	-	3700
Zemlin	-	3500 - 5000
Millard and Kind	-	4100
Greene and Curry	-	5000
Sheela	-	2675

There are several variables which affect the vital capacity. The vital capacity varies with geographical area. Krishnan and Varmed (1932) have reported low vital capacity in South Indians. They attribute this low vital capacity not to race but to the warm climate, less tendency for exercise, low metabolism, and poor cheat expansion. The vital capacity varies with age, weight.

height and body surface area. i.e. the vital capacity can be calculated statistically based on height and weight data. Krishnan and Vareed (1932). Verma et al (1982), Jain and Ramaiah (1967a, 1967b, 1969) have calculated lung capacity baaed on age, height, weight and body surface area for men and women in different age ranges.

Zemlin (1981) has reported that the vital capacity varies with age, sex, height, weight, body surface area, body build, the amount of exercise and other factors. Hutchinson 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.

The other aerodynamic measure that is related to pitch and intensity is rate of airflow. It is the rate at which the air is expelled from the mouth during phonation. For example, during the normal production of a vowel about lOOcc of air passes through the glottis in one second. Mean airflow rate is also related to the regulation of pitch and intensity (Isshiki, 1965, Isshiki, and Von Laden, 1964; Yanagihara and Koike, 1967).

Kunze (1964), Isshiki (1964) have reported the flow rate of l00cc/sec for normal phonation in the modal register. Yanagihara et al (1966) have reported ranges of 110 to 180cc/sec in normal males and in normal females it is low reflecting the generally lower total lung capacity and intensity of voice production.

Thus the review of literature indicates that the vital capacity and mean air flow rate, among other aerodynamic factors, play an important role in determining the pitch and intensity and also the duration for which an individual can sustain phonation. However, it should be mentioned here, that some workers have indicated the mean air flow rate is determined by the glottal resistance. Their relationship between the frequency and mean air flow rate is not yet resolved i.e., whether the mean air flow rate determines the frequency of vibration of the tension (glottal resistance) determines the mean air flow rate is not yet clear or it may be, as some state, that the frequency of vocal cord vibration is determined by the interplay of these two factors. However, it can be stated that the study of these two parameters would help in understanding the process of voice production.

The instability of the exhalation may be indicative of a respiratory or neurologic basis for voice problems. A patient should be able to sustain phonation steadily and continuously for a While. The maximum amount of time an individual can sustain phonation after taking a maximum inhalation is called the maximum phonation duration (MPD). Ptacek and sabder (1963a) suggested that the maximum duration of phonation may be influenced by the frequency and sound pressure level of the phonation. In the high frequency phonations, for both males and females, the phonation time decreases as sound pressure level increased (Lass and Michel, 1969).

Van Riper (1954) states that an individual should be able to sustain phonation for at least 15 seconds. Fairbank (1960) states that 20 to 25 seconds is normal for sustaining a phonation. Short phonation times are associated with laryngeal pathology (von Laden et al 1967).

Arnold (1959) reports that in cases of paralytic dysphonia, phonation time is always shortened to 3-7 seconds similar findings were made in 1942 by Rieben (5 seconds), in 1937 by Luchsinger (3 to 15 seconds) and in 1952 by Brahm (3 to 12 seconds). "This simple measure gives information of the efficiency of the pneumophonic sound generation in the larynx". It also demonstrates the general state of the patient's respiratory coordination (Arnold, 1959).

These aerodynamic and acoustic studies are of great value for clinical work. They provide insight into remedial methods and indicate a rather different emphasis in traditional teaching of 'good' voice production with its greet stress on breathing technique (Wyke, 1969). Therefore these aerodynamic studies have been included as part of routine vocal evaluation by many clinicians,(Gordon et al 1978).

Yanagihara (1969) presents, on the basis of an analysis of data obtained from more than 100 patients, the following diagnostic implications: (a) flowrate more than 300cc/sec with phonation time ratio less than 50% suggests that a low glottal resistance is the dominant contributing factor for the vocal dysfunction which may be diagnosed as hypofunctional voice disorder; (b) flowrate upto about 250cc/sec with phonation time ratio of more than 70% and with high phonation volume - vital capacity ratio suggests that a high glottal resistance is the dominant contributing factor for the vocal dysfunction Which can be labelled as hyperfunctional voice disorder. He further stresses that aerodynamic examinations on phonation can be a valuable adjunct to other physiologic studies for an understanding of laryngeal disorders.

Iwata, van Leden and Williams (1972) have examined 191 patients with various laryngeal diseases with the aid of a pneumotachograph system to measure the airflow during phonatlon. The results have confirmed that the meanflow rate indicates the overall laryngeal dysfunction. The higher mean flow rates corresponded to hypotensive conditions in the larynx, for example, in Unilateral laryngeal paralysis, higher mean airflow rates are observed, While lower mean flow rates are suggested in hypertensive conditions, such as contact ulcer granuloma. Irregularities of the airflow during phonation are reflected am disturbances in the acoustic signals. These functional may be closely related to the pathologic changes in the vocal cords, even in patients with apparently normal mean flow rates. This suggests that the mean flow rate during phonation and especially the degree of airflow fluctuation provides useful quantitative measures of laryngeal dysfunction.

Keman, Gordon, Simpson, and Morton (1975) have studied vocal function by airflow measurements using pneumotachograph respiratory system in both normal and abnormal groups during quiet respiration, and sustained phonation of /i/, /e/ and /a/ at normal, highest, and lowest pitches at comfortable sound pressure level. Many dysphonlc subjects have shown abnormalities intheir breathing patterns even during quiet respiration, while others seem quite normal.

Hippel and Mrowinski (1978) have examined 22 patients with normal vocal function and 33 with voice disorders by pneumotachography. The degree of airflow speed during phonation, the volume of air during phonation, and the duration of phonation were studied in 17 dysphonlc patients with complete closure of the glottis, 16 patients with incomplete glottic closure, and 19 control subjects. The following results were obtained: (a) The parameters of the study were dependent upon the intensity of phonation, (b) the values of the normal group and the dysphonic patients with complete closure of the glottis during phonation were approximately the same; (c) the values of dysphonic patients with incomplete closure of the glottis were significantly different from the other 2 groups. According to the results obtained, pneumotachography appears to be an/useful method in the evaluation of laryngeal function. This is also important in evaluation of treatment.

Aerodynamic studies were performed by zipursky, Fishbein, and Thompson (1982) on 47 patients with psychogenic voice disorders. Pulmonary function data indicated that 40% displayed features characteristic of respiratory abnormalities in the absence of any respiratory symptoms. Phonatory airflow data for a sustained /a/ was obtained along three variables; phonation time ratio, phonation volume-vital capacity ratio, and meanflow rate. Pre- and post- therapy data for these variables were obtained on 15 subjects, of this group 14 showed definite trends toward improvement fallowing treatment.

Amermen and Williams (1979) have investigated the effectiveness of the respirometer as a clinical tool in the diagnosis and management of laryngeal diseases. Airflow measurements of an adult male with a vocal fold polyp are reported. A reapirometric voice profile for this client was developed over a 14 week period representing 13 preoperative test sessions and one post operative test session. The findings incidate that a respirometric voice profile may aid the voice pathologist in determining the effectiveness of ongoing therapy procedures and help provide more objective criteria in determining whether to continue or to terminate voice therapy. Results suggest that the resplrometer is sensitive to small changes in laryngeal function.

In order to evaluate laryngeal function, using the pneumotachographic system, Iwata, Esaki, Iwani, and Takasu (1976) measured the values of maximum phonation time, mean flowrate during sustained phonation, and vocal velocity index before and after surgery in 73 subjects, 33 with unilateral vocal polyps, 36 with bilateral vocal polyps, and 4 with polyps in the anterior commissure. Spectrographic analysis was also done. They have concluded that objective aerodynamic and acoustic examinations for laryngeal function before and after surgery are beneficial for evaluating laryngo microsurgery in phonosurgery.

Bastian, Unger and sasama (1981) have assessed the therapy progress of a group of SO patients with voice function disorders. It was by pneumotachography before and after voice therapy and one year after voice therapy. The intra individual progress controls show a clear improvement of the vocal efficiency. Hyper functional dysphonia is characterized by an increase in the mean flow rate and thephonation volume, and a synchronus decrease in the phonation time. In addition to the mean flow rate, prephonation air volume and phonation delay are parameters of great importance. The improvement of the voice quality can be shown by pneumotachographlc progress after voice therapy, this method is an important aid for the assessment of prognosis of voice disorders.

Isshiki (1964) has investigated the relationship between the voice intensity (SPL), the subglottic pressure, the air flow rate, and the glottal resistance, simultaneous recordings were made of the SPL of voice, the subglottic pressure, the flow rate, and the volume of air utilized during phonation. The glottal resistance, the subglottic power, and the efficiency of voice were calculated from the data. It was found that on very low frequency phonation the flow rate remained almost unchanged or even slightly decreased, with the increase in voice intensity, while the glottal resistance showed a tendency to augment with increased voice intensity. In contrast to this, the flowrate on high frequency phonation was found to increase greatly. While the glottal resistance remained almost unchanged as the voice intensity increased. On the basis of the data it was concluded that at very low pitches, the glottal resistance is dominant in controlling intensity (laryngeal control), becoming less so as the pitch is raised, until at extremely high pitch the intensity is controlled almost entirely by the flow rate (expiratory muscle control).

McGlone (1967) has conducted a study to find out air flow during vocal fry phonation. Five male and five female speakers. Who were free of any voice disorder, were required to sustain vocal fry phonation at three pitch levels; one an arbitrary standard level, another lower than the standard, and a third higher. Recordings were made and analyzed of airflow and acoustic signal of these phonations. This study showed that (a) the fundamentals of vocal fry were lower than those produced in the modal registers, (b) air flow rates were less than found for either modal phonetion or falsetto; and (c) there was no correlation between changes in fry frequency and changes in air flow.

Thus studies have indicated the relationship between vocal function and air flow measurements and further they have also indicated that the vocal function can be assessed by air flow measurements.

Verma et al (1982) have developed a regression equation for indirect examination of ventilatory norms in terms of physical characteristics. Jain and Ramaiah (1967a, 1967b, 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 40-65 years (Jain and Gupta, 1967a, and 1967b). For boys of the age ranging from 7 to 14 years, the ventilatory 'norms' were also estimated using age, height and body weight as predictors (Jain and Ramaiah, 1968a, Jain and Ramaiah 1968b). Verma et al (1982) have developed a regression equations for indirect assessment of some ventilatory 'norms' (viz: 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 mean vital capacity values in Indians were significantly lower than the western subjects (Bhatia, 1929; Bhattacharya, 1963; De and De, 1939; Krishnan and Vareed, 1932; Milledge, 1965; Mukherjee, 1965; Reddy and Sastry, 1944; Telang and Bhagwat, 1941).

With the view to find out the standards of vital capacity in South India, the vital capacities of 103 male medical students of 18 to 29 years of age from different parts of the Madras presidency were estimated, and certain measurements of the body, such as standing height, weight, body surface area, sitting height, and chest circumference, were recorded. The average vital capacity for all the subjects examined was found to be 2.93 liters.

The low vital capacity, generally obtainable in South India, is due not to race or nationality but to the warm to climate, less tendency for exercise, low metabolism and poor cheat 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 monsmokers) in the age range of 20-59 years. It is emphasized that lung function consistently decline with age and the decline is further augmented by cigarette smoking.

Tests of ventilatory function are increasingly used by the clinicians for assessment of patients with respiratory diceases. Normal range of values in older subjects also of value to the clinician for diagnosing and treating the chest diseases. Mandi et al (1976) established that decreases in the vital capacity was more definite in old age. The data of schmidt et al (1973) in subjects between 55-94 years 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.

Shigemori (1977) has measured maximum phoaatlon time, phonation quotient, and mean flow rate in 250 normal and 501 pathological subjects. The normal group consisted of 200 school children of 4 age groups and 50 adults. The pathological group consisted, 122 cases of recurrent laryngeal nerve paralysis, 26 cases of sulcus vocalis, 59 cases of laryngitis, 182 cases of nodule, and polyp, 36 cases of polypoid vocal cord, 18 cases of benign mass, 14 cases of epithelial hyperplasia, and 34 cases of carcinoma. In 115 cases which received phonosurgical treatment, the change in the test values after surgery was related to the patient's own evaluation of his voice. The results and calculations were as follows: (a) The older the subject, the greater the average maximum phonation time, (b) the older the subject, the greater the phonation quotient was among the normal school children, (c) The older the subject, the greater the average airflow rate measured with a resplrometer for easy phonation among the normal subjects, (d) among the cases of various pathologies, those of recurrent laryngeal nerve paralysis presented abnormal test value* most frequently. The glottic incompetence appears to account for the abnormal test values in many eases, (e) in the pathological cases, the frequency of abnormal test values was the greatest in the maximum phonation time and the least in the mean air flow rate, (f) high negative correlations were observed between the maximum phonatioa time and the phonation quotient in both the normal and pathological air flow rate, and the over 2 measures were not very high, and (g) among various laryngeal diseases, the test values agree best with the patient's own evaluation of his voice in recurrent laryngeal nerve paralysis, Among the three test values, the maximum phonation time appeared to reflect best the patient's own evaluation of the post-operative change in his voice.

Jayaram (1975) has examined normals and dysphonics. 30 males and 40 females in the group of normals and 21 males and 12 females in dysphonic group - of adult age range. The results were as follows:

The maximum duration of phonation ranged from 16 seconds to 38 seconds in normal males and from 6 seconds to 25 seconds in dyaphonic males. The female subjects in normal and dysphonic groups presented to seconds to 27 seconds and 5 seconds to 25 seconds as their range of maximum duration of phonation respectively

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 1500 cc to 3000cc in females of the dysphonic group.

The mean air flow rate during phonation ranged from 62.4 cc/sec. to 275cc/sec. in normal males and from 95cc/sec to 660 cc/sec. in dysphonic males. The females in the normal group presented a range of 71.42 cc/sec to 214.23 cc/sec and in dysphonic females, it ranged from 100 cc/sec to 257.14 cc/sec.

Another indicator of the vocal function is the ratio of vital capacity to maximum phonation duration (sawashima, 1966). Hirano et al (1966) named this ratio as "phonation quotient" (PQ).

The total air volume used during maximum sustained phonation (phonation volume, PV, by Yanagihara et al., 1966) is usually less than the vital capacity (Gutzman and Loewy, 1920; Yanagihara et al., 1966, Yanagihara and Koike, 1967; Isshiki at al., 1967; Yoshioka et al., 1977). The ratio of PV to VC was found to be 50.4 to 73.0 percent by Yanagihara et al (1966), 68.7 to 94.5 percent by Isshiki et al (1967), and 66 to 114 percent by Yoshioka et al (1977), It indicates that the PQ is usually larger than mean air flow rate during maximum sustained phonation.

Hirano et al (1968) have demonstrated a high positive relationship between MFR measured during maximum sustained phonation and PQ in normal subjects. Iwata and Von Leden (1970) have recommended the use of PQ as an indicator of air usage when MFR cannot be directly determined.

The normal average values of PQ in adults ranges from 120 to 190 cc/sec (Sawashima, 1966; Hirano et al 1968; Shigemori, 1977;

Yoshioka et al 1977). Hirano et al (1968), Iwata and Von Leden (1972), Shigemori (1977) and Yoshioka et al (1977) have reported a markedly elevated PQ in most of the laryngeal pathological patients.

Koike and Hirano (1968) have derived one more measure which they referred to as the "vocal velocity index"(VVI). This team applies to the ratio of mean air flow rate to vital capacity. Iwata end Von Leden (1970) have selected one hundred thirty-eight patients with different laryngeal diseases and voice disorders. They were subjected to aerodynamic measurements of sustained vowel phonation. The vocal velocity index was computed for each individual patient and for the different organic and functional diseases. The results on VVI were compared with physiological and psychoacoustic reports. The results suggested the application of the VVI as a useful objective measure of laryngeal efficiency, and differential diagnosis of dysphonia.

The review of literature indicates that the aerodynamic measurements, namely, vital capacity and mean air flow rate provide useful information in the assesment of respiratory and phonatory systems and thus they have gained clinical importance.

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 Spirormeters are in use.

A simple spirometer consists of A vessel placed inverted like Bell in A Jacket of Water. A wide air passage going through the center of the jacket communicates with the bell, the other end of the passage is connected through a corrugated impervious tubing to a mouthpiece. When the subject breathes out through it, the expired air lifts the bell. A counter weight Attached to a chain running over a pulley balances the weight of the bell. A pointer records the volume contained in the apirometer. The scale is marked either on a wheel fixed over the pulley or on the tube containing the counter weight,

Most clinical and research data reporting airflow parameters have been collected from conventional respirometers or pneumotachographic - pressure transducer systems, which are both expensive and nonportable. Hany 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, contact 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 mmmm air flow rate. The PQ will be calculated from the obtained vital capacity and maximum phonation duration as stated earlier i.e. $PQ = \frac{VC}{MPD}$. It is valid for use with young (age 16+) and older adults according to Rau and Beckett (1984).

She vital capacity can or calculated from the height and weight of the subject as reported to the above literature. Therefore the instruments required to determine VC will be inexpensive. One stop watch, weighing machine and a tape are sufficient to determine VC and MPD. Thus using these two measures it would be possible to calculate PQ and then find out the MFR by means of the reported equation.

therefore the present study aimed at (1) developing nomogram based on height and weight to predict the vital capacity,(2)to find out the relationship between PQ and MFR, as measured, and then further (3) to predict and to validate the above methods of determining the VC based on height and weignt and predicting the MFR based VC and MFD i.e., PQ in normal subjects.

METHODOLOGY

The study was conducted to findout the possibilities of /l/ Predicting vital capacity baaed on height and weight of an individual; /ii/ To predict MFR based on vital capacity and maximum phonation duration and to validate the methods.

Part 1 A: Subjects: 30 males, ape ranging from 18 to 29 years ; and 30 females, age ranging from 17 to 25 years served as subjects for the study.

Subjects were chosen on the basis of age and absence of any vocal pathology. Normal vocal functioning was determined by questioning vocal usage, histories for evidence of vocal or laryngeal problems. No subject was included who had any history of abnormal vocal use or vocal problems, chronic smokers, end the persons who had breathing problems (The subjects were selected randomly based on the above criteria).

Equipment:
1. Expirograph (Toshnival & co)
2. Weighing machine
3. Stop watch
4. Measuring tape

PROCEDURE: All subjects were made to stand in errect position (a) The following instructions were given to the subject. "Inhale as deeply as you can through your mouth, when you think that you have filled your lungs maximally, blow air through this mouth piece as such as you can in one breath without permitting the air to leak cut". After the instruction the examiner demonstrated it. The subject was trained to keep the mouth piece tightly to the mouth and to blow into the mouth piece. As the subject was blowing into the mouth piece the needle of the expirograph kept moving on the calibrated paper thus sharing the volume of the air expired.

The subject, after deep inspiration, expired the air into the mouth piece of expirograph, to the maximum extent possible. The reading on the expirograph showed the total volume of air expired.

Thus vital capacity for each subject was measured. The procedure was carried out, three times for each subject with an encouragement verbally by the experimenter to increase the volume of expiration each time.

Data were gathered directly from expirograph calibrated paper. The air blown was measured in centimeter on the expirographic paper. It was then multiplied by 300 to give the vital capacity in cc.

(b) The phonation volume and phonation time were measured using the following instruction: "Inhale as deeply as you can through your mouth. When you think that you have filled your lungs maximally, in–tone the souhd /a/ as long as you can through this mouth piece, until you completely run out of air. While intoning the sound/a/ through this mouth piece, the air should not leak from the sides. Hold it tightly against the mouth. Be careful to use a comfortable loudness level and please do not stop until you completely run out of air".

Subsequent trials were preceded by the following instruction, "try to prolong the sound longer this time*. The atop watch was started at the initiation of each phonation of /a/ and stopped at the termination of each phonation by the investigator. This provided the phonation time. The air collected during the phonation of /a/ was noted down from expirographic paper in terms of cc.

The mean airflow rate was calculated for each subject, for each trial, using the formula $\frac{FV}{PT}$ (cc/seconds).

(c) The maximum phonation duration of /a/ was obtained using the following instruction; "Inhale as deeply as you can through your mouth. When you think that you have filled your lungs maximally, intone the found /a/ as long as you can, until you completely run out of air. While intoning the sound/a/ be careful to use a comfortable loudness level, and please donot stop until you completely run out of air" . Subsequent trials were preceded by the following instruction: "Try to prolong the sound longer this time".

The atop watch was started at the initiation of each phonation and stopped at the termination of each phonation and noted down the duration for which phonation was sustained in terms of seconds. Thus the maximum duration of phonation was determined for each subject using three trials. The longest phonation duration was considered as the maximum phonation duration for that individual.

Each subject thus performed three trials for each measurement, All trials were recorded, and the best effort for eg. the largest vital capacity, longest phonation duration was considered as the vital capacity and maximum phonation duration for that individual and were used for analysis. To minimize fatigue effects, greater than 30 seconds rest period was inserted between trials for each parameter, and a rest period of 3 to 5 minutes occurred between parameters.

Each sabjects weight and height were measured in terms of kilograms (Kg) and centimeters (cm) respectively.

Using the data of vital capacity, height and weight, a nomograp (figure 1) was constructed. The scales were adjusted, so that, majority of the subjects' measured vital capacity, coincided with the values orbitrarily placed on the scale. Two separate scales were constructed for males and females as shown ia figure 1.

The phonation quotient was calculated from the above data using the formula $PQ = \frac{VC}{MPD}$

The relationships between mean air flow gate and phonation quotient were determined.

Part 1. B: The above measures were repeated on 10 subjects (five males and five females) to find out the reliability of the measurements. They were selected randomly. The values obtained were within ± 50 cc for vital capacity and ± 3 seconds for maximum phonation duration, except for one subject who showed a variation of ± 400 cc in vital capacity. Therefore the Measurement were considered as reliable.

Part II: 15 males, age ranging from 19.5 years to 30 years, 15 females, age ranging from 18 years to 24 years. These subjects were not included in Part I of this study. The height and weight of these subjects were determined and the vital capacity was predicted using the nomogram prepared in Part I of this study. Then the maximum phonation duration was measured as in Part I.

The phonation quotient was calculated using the above data. i.e. using the vital capacity (estimated) and maximum phonation duration measurements. The formula $PQ = \frac{VC}{MPD}$ was used.

The mean air flow rate was calculated by applying the equation given by Rau and Beckett (1984) (MFR = 77 + .236 PQ). This was compared with the results of Part I of the experiment.

Rau and Beckett (1984) used the following method to get mean airflow rate:

In attaining the regression equation, the phonation quotient was regressed on the mean flow rate. The statistical equation was derived from the following :

$$Y = A \text{ (a constant) } = BX.$$

The vital capacity, and mean airflow rates were measured using expirograph, for the same subjects as in Part I of this experiment The phonation quotient was calculated using vital capacity (obtained) and maximum phonation duration. The vital capacity (estimated), the phonation quotient (estimated) and the mean airflow rates (estimated) were compared with the vital capacity (obtained), phonation quotients (obtained) and mean airflow rates (obtained) respectively, further correlation coefficients were found out between estimated and obtained phonation quotient and mean airflow rates.

RESULTS AND DISCUSSION

Part-l: Data obtained from the chirograph and height and weight are shown in Table 1 and 2, for males and females respectively. The vital capacity in males tanged from 2400cc to 3750 cc. The average vital capacity in males was 3120cc of air with standard deviation of 330cc of air. In females the vital capacity ranged from 1750cc to 2550cc of air. The average vital capacity waa 2130cc of air with standard deviation of 200cc of air.

The height and weight in males ranged from 157 em to 177 cm and 42kg to 85kg respectively. The average height waa 168.08 cm and weight was 55.38kg. with standard deviations of 5.8cm and 8.72kg. respectively.

The height and weight in females ranged from 1495 cm to 165 cm and 40 Kg to 63 kg respectively. The average height was 156.65 cm and weight was 47.6kg with standard deviations of 4.35 cm and 5.27 kg respectively. There is significant difference between males and females in terms of height and weight and hence the null hypothesis (ii) is rejected.

Using the height, weight and vital capacity obtained a 'Nomogram' was constructed for males and females separately (fig.1).

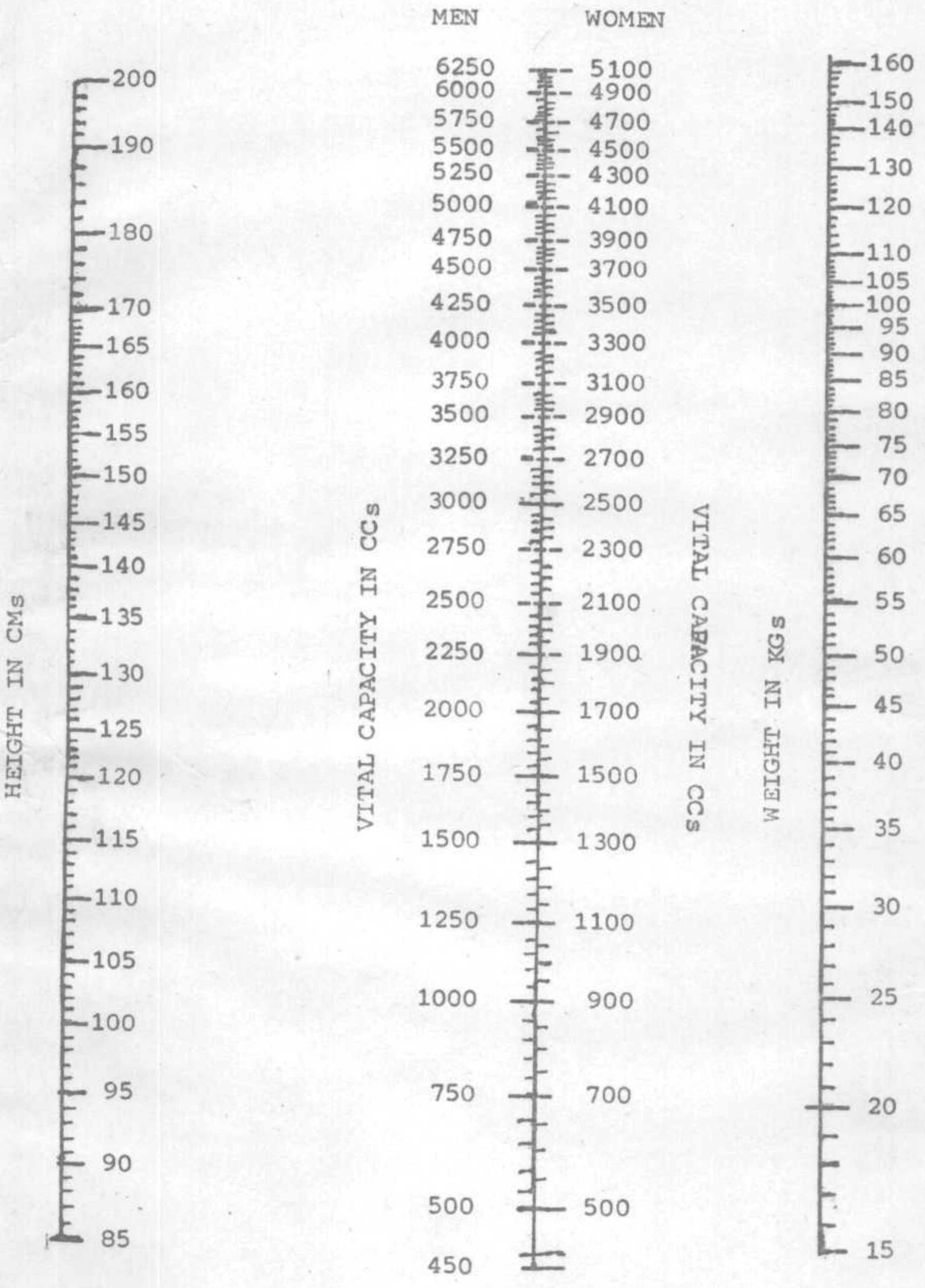
The 'nomogram' constructed was such that the measured vital capacity, namely the highest value in three trials, fell within

Sl.NO.	Age (in years)	Vital capacity (CC)	Height (cm)	Weight (kg)
1	20	3000	164	63
2	23	2850	170	49
3	22	3000	174	51
4	21	3450	161	64
5	19	3150	172	54
6	22	2850	161	48
7	22	3300	172	67
8	24	3750	175	85
9	21	2700	160	45
10	23	3400	173	52
11	24	3150	172	53
12	18	2400	164.5	45
13	25	3150	157	57.5
14	20	2850	163	52
15	19	2700	173	47
16	18	3150	166	62.5
17	18	3000	163	53.5
18	20	3450	176	64
19	18	3300	177	55
20	26	3150	161	53
21	21	2600	163	42
22	20	2650	170.5	46
23	20	3400	171.5	56
24	21	3100	170.5	50
25	21	3750	172.5	68
26	19	3150	166	49
27	29	3250	159	62
28	25	2850	174	52
29	27	3400	165	57
30	18	3600	176	59
Mean	21.47	3120	168.08	55.38
SD	2.84	330	5.8	8.72

Table-1: Age, Vital Capacity(in cc), Height(in cm) and Weight (in Kg) in males.

Sl.No.	Age (in years)	Vital capacity (cc)	Height (cm)	Weight (Kg)
1	22	2250	165	46
2	22	2100	156	42
3	21	1950	160	45
4	21	2250	154	45
5	19	2200	150	50
6	20	1950	162	42
7	22	2250	160	53
8	20	1800	155	42
9	24	2400	161	52
10	17	2550	157	63
11	21	2550	153	55
12	20	2100	156	44
13	21	1950	153	46
14	19	2250	150	48
15	29	1950	154	50
16	20	2250	164	53
17	20	2100	162.5	49.5
18	18	1950	154.5	42
19	18	2000	149.5	44
20	21	1800	154.5	40
21	22	2400	156.5	51
22	21	2000	149.5	55
23	22	2250	155.5	44
24	22	2250	165	46
25	19	2200	159	53
26	21	2100	159	50
27	21	2250	154	41
28	21	1750	154	40
29	25	2000	154	49.5
30	24	2200	155	47
Mean	20.8	2130	156.65	47.6
SD	1.74	200	4.35	5.27

Table-2: Age, Vital Capacity (in cc). Height (in cm) and Weight (in Kg) in females.


MEN
WOMEN
HEIGHT IN CMs
200
190
180
170
165
160
155
150
145
140
135
130
125
120
115
110
105
100
95
90
85
VITAL CAPACITY IN CCs
6250
6000
5750
5500
5250
5000
4750
4500
4250
4000
3750
3500
3250
3000
2750
2500
2250
2000
1750
1500
1250
1000
750
500
450
5100
4900
4700
4500
4300
4100
3900
3700
3500
3300
3100
2900
2700
2500
2300
2100
1900
1700
1500
1300
1100
900
700
500
VITAL CAPACITY IN CCs
WEIGHT IN KGs
160
150
140
130
120
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15

±300cc of air for males and famales on the arbitrarily marked scale. Thus the vital capacity could be related to height and weight for all the 30 males and 30 females on the respective nomogram. Hence the hypothesis stating that thete is a relationship between the vital capacity, and height and weight of an individual is accepted.

The vital capacity, maximum phonation duration and PQ are shown in Table-3 and 4 for males and females respectively.

The maximum phonation duration ranged from 17 seconds to 40 seconds for male group. The average maximum phonation duration was 24.63 seconds with standard deviation of 5.08 seconds for male group, in female group the maximum phonatioa duration ranged from 10 seconds to 24 seconds. The average maximum phonation duration was 18.17 seconds with standard deviation of 4.14 seconds. The standard deviations of maximum phonation durationalso confirms that the groups were homogeneous. There is a significant difference between males and females in terms of maximum phonation duration and hence the null hypothesis stating that there is no significant difference between males aad females in terms of MRD is rejected.

The mean airflow rates and phonation quotients were calculated using the formulas (MFR = $\frac{PV}{PT}$; PQ = $\frac{VC}{MPD}$) described by Iwata and Von Laden (1970).

Sl. No.	Age (in years)	VC (in cc)	MPD (in seconds)	PQ (= $\frac{??}{???}$) (cc/sec)
1	20	3000	22	136.36
2	23	2850	25	114.00
3	22	3000	22	136.36
4	21	3450	26	132.69
5	19	3150	29	108.62
6	22	2850	25	114.00
7	22	3300	22	150.00
8	24	3750	26	144.23
9	21	2700	24	112.50
10	23	3400	27	127.78
11	24	2150	26	121.15
12	18	2400	19	126.32
13	25	3150	40	78.75
14	20	2850	18	158.33
15	19	2700	19	142.11
17	18	3000	22	136.36
18	20	3450	24	143.75
19	18	3300	23	143.48
20	26	3150	33	95.45
21	21	2600	19.5	133.33
22	20	2650	28	94.64
23	20	3400	18.5	183.78
24	21	3100	35	88.57
25	21	3750	19	197.37
26	19	3150	17	185.29
27	29	3250	23	141.30
28	25	2850	28	101.79
29	27	3400	28	121.43
30	18	3600	25	144.00
Mean	21.47	3120	34.63	131.16
SD	2.84	330	5.08	27.04

Table 3: Age, vital capacity (in cc), maximum phonation Duration (in seconds) and calculated measure of phonation quotient taken from expirograph in males.

Sl. No.	Age (in years)	VC (in cc)	MPD (in seconds)	PQ (= $\frac{??}{???}$) (cc/sec)
1	20	3000	22	136.36
2	23	2850	25	114.00
3	22	3000	22	136.36
4	21	3450	26	132.69
5	19	3150	29	108.62
6	22	2850	25	114.00
7	22	3300	22	150.00
8	24	3750	26	144.23
9	21	2700	24	112.50
10	23	3400	27	127.78
11	24	2150	26	121.15
12	18	2400	19	126.32
13	25	3150	40	78.75
14	20	2850	18	158.33
15	19	2700	19	142.11
17	18	3000	22	136.36
18	20	3450	24	143.75
19	18	3300	23	143.48
20	26	3150	33	95.45
21	21	2600	19.5	133.33
22	20	2650	28	94.64
23	20	3400	18.5	183.78
24	21	3100	35	88.57
25	21	3750	19	197.37
26	19	3150	17	185.29
27	29	3250	23	141.30
28	25	2850	28	101.79
29	27	3400	28	121.43
30	18	3600	25	144.00
Mean	21.47	3120	34.63	131.16
SD	2.84	330	5.08	27.04

Table 3: Age, vital capacity (in cc), maximum phonation Duration (in seconds) and calculated measure of phonation quotient taken from expirograph in males.

Sl. No.	Age (in years)	VC (in cc)	MPD (in seconds)	PQ (= $\frac{??}{???}$) (cc/sec)
1	22	2250	27	83.33
2	22	2100	17	123.53
3	21	1950	13	150.00
4	21	2250	20.5	109.76
5	19	2200	12	183.33
6	20	1950	14	139.29
7	22	2250	20	112.50
8	20	1800	16	112.50
9	24	2400	24	100.00
10	17	2550	21	121.43
11	21	2550	17	150.00
12	20	2100	21	100.00
13	21	1950	18	108.33
14	19	2250	18.5	121.62
15	20	1950	23	84.78
17	20	2100	16	131.25
18	18	1950	15	130.00
19	18	2000	17	117.65
20	21	1800	10	180.00
21	22	2400	17	141.18
22	21	2000	11	181.82
23	22	2250	23	97.83
24	22	2250	24	93.75
25	19	2200	15	146.67
26	21	2100	13	161.54
27	21	2250	22	102.27
28	21	1750	20	87.50
29	25	2000	21	95.24
30	24	2200	21	104.76
Mean	20.8	2130	18.17	123.23
SD	1.74	200	4.14	28.04

Table 3: Age, vital capacity (in cc), maximum phonation Duration (in seconds) and calculated measure of phonation quotient taken from expirograph in females.

The mean air flow rate (obtained) ranged from 67.5 cc/sec to 135 cc/sec. The average mean air flow rate was 105.79 cc/sec with standard deviation of 19.25 cc/sec in males. In females, the mesa air flow rate (obtained) ranged from 62.5 cc/sec. to 141.67 cc/sec. The average MFR was 98.34 cc/sec with standard deviation of 20.97 cc/sec.

Farther mean air flow rate was also obtained for each subject using the formuls (MPR = 77 + .236 PQ) given by Ram and Beckett (1984) for both males and females. Table (5) and (6) show the estimated and obtained mean air flow rates for males and females respectively. The estimated mean air flow rate ranged from 95.59 cc/sec. to 123.58 cc/sec and an average mean air flow rate of 107.96 cc/sec with standard deviation of 6.38 cc/sec for male group. In female group, the mesa air flow rate (estimated) ranged from 96.67 ec/sec to 120.27 cc/sec. The average mean air flow rate (estimated) was 106.0sec/sec with standard deviation of 6.62 cc/sec.

Further using linear correlation the correlation coefficients between obtained and estimated mean air flow rate was calculated. It was 0.71 for males and 0.87 for females. This high positive correlation indicates that there is no significant difference between obtained and estimated mean flow rates. This it would be possible to obtain mean flow rate When phonation quotient is given and further phonation quotient can be determined using maximum phonation duration and vital Capacity. Vital capacity can be

Sl. No.	Age (in years)	PQ (= $\frac{??}{???}$) (cc/sec)	MFR obtained (= $\frac{??}{??}$)(cc/sec)	MFR(Estimated) (MFR= 77+ .236 PQ)
1	20	136.36	105.00	109.18
2	23	114.00	108.00	103.90
3	22	136.36	119.05	109.18
4	21	132.69	126.00	108.31
5	19	108.62	108.62	102.63
6	22	114.00	84.78	103.90
7	22	150.00	129.55	112.40
8	24	144.23	121.43	111.04
9	21	112.50	87.50	103.55
10	23	127.78	75.00	107.16
11	24	121.15	115.38	105.59
12	18	126.32	79.41	106.81
13	25	78.75	67.50	95.59
14	20	158.33	134.48	114.37
15	19	142.11	133.33	110.54
17	18	136.36	112.50	109.18
18	20	143.75	105.00	110.93
19	18	143.48	135.00	110.86
20	26	95.45	85.71	99.53
21	21	133.33	100.00	108.47
22	20	94.64	85.71	99.34
23	20	183.78	108.62	120.37
24	21	88.57	80.88	97.90
25	21	197.37	130.56	123.58
26	19	185.29	134.38	120.73
27	29	141.30	95.00	110.35
28	25	101.79	101.00	101.02
29	27	121.43	102.00	105.66
30	18	144.00	110.00	110.98
Mean	21.47	131.16	105.79	107.96
SD	2.84	27.04	19.25	6.38

Table 5: Age, phonation quotient and mean air flow rate taken from the expirograph and mean air flow rate estimated derived by applying the equation MFR = 77 + .236 PQ in males.

Sl. No.	Age (years)	PQ (= $\frac{??}{???}$)	MFR (obtained) (= $\frac{??}{??}$)(cc/sec)	MFR(estimated) (MFR= 77+.236 PQ)
1	22	83.33	65.00	96.67
2	22	123.53	110.00	106.15
3	21	150.00	100.00	112.40
4	21	109.76	80.49	102.90
5	19	183.33	141.67	120.27
6	20	139.29	96.43	109.87
7	22	112.50	105.00	103.55
8	20	112.50	90.00	103.55
9	24	100.00	85.71	100.60
10	17	121.43	105.00	105.40
11	21	150.00	120.00	112.40
12	20	100.00	92.86	100.60
13	21	108.33	100.00	105.70
14	19	121.62	100.00	105.70
15	20	84.78	80.49	97.01
17	20	131.25	110.00	107.98
18	18	130.00	116.67	107.68
19	18	117.65	94.12	104.77
20	21	180.00	135.00	119.48
21	22	141.18	117.64	110.32
22	21	181.82	130.00	119.91
23	22	97.83	78.26	100.09
24	22	93.75	66.67	99.13
25	19	146.67	136.40	111.61
26	21	161.54	100.00	115.12
27	21	102.27	90.90	101.14
28	21	87.50	62.50	97.65
29	25	95.24	69.40	99.48
30	24	104.76	86.80	101.72
Mean	20.8	123.23	98.34	106.08
SD	1.74	28.04	20.97	6.62

Table-6: Age, phonation quotient, and mean air flow rate taken from the expirograph and mean air flow rate estimated derived by applying the equation MFR = 77 + .236 PQ in females.

determined when height and weight are given using nomograms. The examination of tables 5 and 6 showing the phonation quotient and mean air flow rates in males and females reveals that the phonation quotient was always greater than mean flow rate (except in one male subject Where phonation quotient and mean air flow rates was same). Similar report has been made by Rau and Beckett (1984) Who states "as warn true with subjects reported on in their study (Iwata and Von Leden, 1970), phonation quotient calculated for the 19 subjects always reflected larger values than the mean flow rates for the same subjects".

The vital capacity in case of males which ranged from 2400 cc to 3750 cc and 1750 cc to 2550cc in case of females with the mean of 3120 cc and 2130 cc respectively, These were within normal limits When compared with following data. Jayaram (1975) has reported the vital capacity value ranged from 2850cc to 3450CC in males and 1650CC to 3000cc in case of females.

Krishnan and Vareed (1932) have indicated that the average vital capacity in South Indian adult males was 2930 cc. Hence the null hypothesis stating that there is no significant difference between males and females in terms of vital capacities is rejected.

The mean air flow rate in case of males which ranged from 67.5 cc/sec to 135 cc/sec with the mean of 105.79 cc/sec and in females it ranged from 62.5 cc/sec to 141.67 cc/sec with the mean of 105.79 cc/sec and in females it ranged from 62.5 cc/sec to 141.67 cc/sec with the mean of 98.34 cc/sec. Kunje (1964), Isshiki (1964) have reported the flowrates of 100 cc/sec for normal phonation in modal registers. Jayaram (1975) has reported the flow rate range of 62.4 cc/sec to 275 cc/sec in males and 71.42 cc/sec. to 214.23 cc/sec in females.

These findings imply that the subjects included in this study were healthy and normal with reference to vital capacity and mean air flow rates.

Part-II of the experiment was conducted to find out the predictive validity of the system developed i.e. to predict the mean air flow rate based on height and weight and maximum phonation duration.

Part-II: Based on the height and weight made on 15 male and 15 female subjects the vital capacity was predicted for each subject (vital capacity estimated). Further the phonation quotients were predicted based on the vital capacity (estimated) and maximum phonation duration (measured) for all the 30 subjects. Then the vital capacity and mean air flow rates were determined for all the subjects usingroutine procedure (which were indicated as vital capacity obtained and mean air flow rate obtained. They are presented in Table-7, 8, 11 & 12.

The height, the weight, the vital capacity (estimated) and the vital capacity (obtained) is presented in Tables 7 and 8 for males and females separately. The vital capacity (estimated) ranged from 2650 cc to 3500 cc with the mean of 3080 cc and

Sl.No.	Age	Height (cm)	Weight (Kg)	Estimated vc(cc)	Obtained VC(cc)	Difference
1	19.5	170	60	3250	3000	-250
2	20	169.5	54	3050	3150	+100
3	23	156.5	51	2725	2750	+25
4	24	165	55	3000	2350	-150
5	30	168	45	2725	2550	-175
6	20	164.5	56	3050	3250	+200
7	23	166.5	59	3200	3400	+200
8	30	168.5	69	3500	3750	+250
9	22	176	65	3500	3800	+300
10	20	160.5	50	2750	2350	+100
11	26	170	65	3400	3500	+100
12	21	163.5	60	3125	3200	+ 75
13	22	173	50	3275	3250	- 25
14	26	161	46	2650	2500	-150
15	20	164	54	2950	3150	+200
Mean	23.43	166.77	57.13	3000	3130	
SD	3.72	5.03	7.50	230	290	

Table-7: A comparison of estimated VC (from nomogram), and obtained VC (from expirograph) measures in males.

Sl.NO.	Age	Height	Weight	Estimated VC	Obtained VC	Difference
1	18	150	45	2090	2000	+50
2	21	161	48	2250	2500	-250
3	21	156	45	2150	2000	+150
4	21	153	49	2250	2250	-0
5	21	150	38	1850	2000	-150
6	20	161	49	2300	2500	-200
7	20	154.5	42	2050	2250	-200
8	18	162	53	2400	2500	-100
9	20	153.5	60	2550	2750	-200
10	19	152	45	2075	2000	+75
11	19	155.5	42.5	2050	1950	+100
12	19	158.5	42	2075	1950	+125
13	21	157.5	55	2375	2200	+175
14	19	162	49	2300	2300	0
15	24	159	47	2150	2200	-50

Table-8: A comparison of estimated VC (from Nomogram) and obtained VC (from expirograph) measures in females.

standard deviation of 280cc for males. In females, the vital capacity (estimated) ranged from 1850 cc to 2500 cc with the mean of 2200cc and standard deviation of 180 cc.

The vital capacity (obtained) ranged from 2500 cc to 3800 cc with the mean of 3130 cc and standard deviation of 390 cc for males. In case of females, the vital capacity (obtained) ranged from 1950cc to 2750cc with the mean of 2230cc and standard deviation of 250cc. The difference between obtained and estimated vital capacity measure was within ± 300cc of air for males and females. It is presented in Tables 7 and 8. There was no significant difference between two and hence the null hypothesis stating that there is no difference between estimated and obtained vital capacities in males and females is accepted. Therefore it can be concluded that vital capacity (estimated) based on height and weight of an individual using nomograms is within ± 300cc for both males and females. Thus the presently developed nomograms based on normal data have predictive ability.

The phonation quotient (estimated and obtained) is given in Tables 9 and 10 for both males and females separately. The phonation quotient (estimated) ranged from 100 cc/sec to 176.47 cc/sec with the mean of 131.85 cc/sec and standard deviation of 23.59 cc/sec. for males. In case of females, the phonatlon quotient (estimated) ranged from 102.38 cc/sec to 179.17 cc/sec with the mean of 125.74 cc/sec and standard deviation of 22.96 cc/sec.

Sl.No.	Age	Height	Weight	MPD	Expected	Obtained	Difference
1	19.5	170	60	26	125.00	115.38	9.62
2	20	169.5	54	18	169.44	175.00	-5.56
3	23	156.5	51	17	160.29	161.17	-0.88
4	24	165	55	17	176.47	167.65	8.82
5	30	168	45	18	151.39	141.67	9.72
6	20	164,5	56	27	112.96	120.37	-7.41
7	28	166.5	59	22	145.45	154.55	-9.1
8	30	168.5	69	32	109.38	117.19	-7.81
9	22	176	65	35	100.00	108.57	-8.57
10	20	160.5	50	25	110.00	114.00	-4.0
11	26	170	65	27	125.93	129.63	-3.7
12	21	168.5	60	28	111.61	114.29	-2.68
13	22	173	58	24	136.46	135.42	1.04
14	26	161	46	22	120.45	113.64	6.34
15	20	164	54	24	122.92	131.25	-8.33
Mean	23.43	166.67	57.13	24.13	131.85	133,46	
SD	3.72	5.03	7.50	5.36	23.69	21.83	

Table-9: A comparison of estimated PQ (from estimated vc and MPD), and obtained PQ (from expirograph) measures in males.

Sl.No.	Age	Height	weight	MPD	Estimated PQ	Obtained PQ	Difference
1	18	150	45	16	128.13	125.00	3.13
2	21	161	48	19	116.42	131.53	-13.16
3	21	156	45	12	179.17	166.67	12.5
4	21	153	49	19	118.42	118.42	0
5	21	150	38	16	115.63	125.00	- 9.37
6	20	161	49	21	109.52	119.05	- 9.53
7	20	154.5	42	16	128.13	140.63	-12.5
8	18	162	53	22	109.09	113.64	- 4.55
9	29	158.5	60	16	159.38	171.88	-12.5
10	19	152	45	20	103.75	100.00	3.75
11	19	155.5	42.5	19	107.89	102.63	5.26
12	19	158.5	42	14	148.21	139.29	8.92
13	21	157.5	55	16	148.44	137.50	10.94
14	19	162	49	21	109.52	109.52	0
15	24	159	47	21	102.38	104.76	-2.38
Mean	19.67	156.97	47.37	19.87	125.74	127.07	
SD	1.18	4.4	5.63	2.95	22.96	21.52	

Table-10: A comparison of estimated PQ (from estimated VC and MPD) and obtained PQ (from expirograph) measures in females.

The phonation quotient (obtained) ranged from 108.57 cc/sec to 175.cc/sec with the mean of 133.46 cc/sec and standard deviation of 21.83 cc/sec for males. In ease of females, the phonation quotient (obtained) ranged from 100.00 cc/sec to 171.88 cc/sec with the mean of 127.07 cc/sec and standard deviation of 21.52 cc/sec.

there was no significant difference between the two means for both males and females and hence the null hypothesis stating that there is no significant difference between estimated and obtained PQ in males and females is accepted.

Thus it was possible to predict phonation quotient based on the vital capacity (estimated) derived using nomograms and the maximum phonation duration obtained in 30 subjects. Therefore it can be concluded that it is possible to obtain phonation quotient based on maximum phonation duration, and height and weight using nomograms.

the equation (MPR = 77 + .236 PQ) (which was obtained by regressing the phonation quotient on the mean flow rate), derived by Rau and Beckett (1984), was used to calculate mean airflow rate. The mean airflow rate (obtained and estimated) is given in Table 11 and 12 for males and females separately.

The mean airflow rate (estimated) ranged from 100.60cc/sec to 118.65 cc/sec with the mean of 108.58 cc/sec and standard deviation of 5.76 cc/sec. In case of females, the mean airflow rate (estimated) ranged from 101.16 cc/sec to 119.20 cc/sec with the mean of 106.68 cc/sec and standard deviation of 5.42 cc/sec.

The mean airflow rate (obtained) ranged from 85.29 cc/sec to 143.33 cc/sec with the mean of 110.99 cc/sec and standard deviation of 17.87 cc/sec in case of males. In case of females, it ranged from 86.80 cc/sec to 125 cc/sec with the mean of 106.20 cc/sec and standard deviation of 13.45 cc/sec.

There was no significant difference between the two measures for both males and females and hence the null hypothesis stating that there is no significant difference between estimated and obtained MFR in males and females is accepted.

Table-13 indicates correlation coefficient between phonation quotients (estimated and obtained) and mean airflow rates (estimated and obtained) among 30 young adult subjects.

Results show no significant difference between mean airflow rate and phonation quotient measures. These results are consistent with findings reported by Hirano et al (1968), Rau and Beckett (1984) and hence the null hypothesis stating that there is no correlation between PQ and MFR in males and females is rejected. The results also show a significant correlation between mean air flow rate and phonation quotient (estimated and obtained). Although the regression estimated wean airflow rates were typically 9-10% lower than those determined by the expirograph, there was a high, positive correlation between the actual and estimated mean airflow rates (r = 0.76).

Variable*	PQ_o	PQ_e	MFR_o
PQ_e	0.94		
MFR_o	0.86	0.81	
MFR_e	0.92	9.97	0.76

Table-13: Correlation coefficients for phonation quotients and mean air flow rate among 30 young adult subjects among the obtained (from expirograph) PQ and MFR and estimated phonation quotient and MFR.

* PQ_o represents the phonation quotient measure obtained from the expirograph while PQ_e represents the phonation quotient measure estimated. MFR_o and MFR_e represents the mean flow rate obtained from the expirograph and the mean air flow rate estimated respectively.

As reported by Jayaram (1975), the vital capacity was more in ease of males than in females, the present study also shows higher vital capacity in males than in females. Longer maximum phonation durations have been shown by males than in females. Similar reports have been made by Jayaram (1975), Fairbank (1960).

The results of the study indicate that height and weight of an individual can be used to predict vital capacity. Based on this estimated vital capacity, phonation quotient can be calculated. This estimated phonation quotient helps in determining mean air flow rate using the formula MFR = 77+.236 PQ. Hence the hypothesis stating that there is a significant correlation between phonation quotient and mean air flow rates in normal adult subjects and mean air flow rate can be calculated using the phonation quotient values is accepted.

Importance of measurement of mean air flow rate in the diagnosis and treatment of voice disorders is well known (Beckett, 1971? Hirano, Koike and Von Leden, 1968; Isshiki, 1964, 1965; Isshiki and Von Leden, 1964; Iwata and von Laden, 1970; Yanagihara and Koike, 1967; Yanagihara, Koike and Von Laden, 1966; Yanagihara and von Leden, 1967). As Rau and Beckett (1984) states that mean air flow rate is a reliable indicator of proper air usage during phonation. Further the mean air flow rate is also related to the regulation of pitch and intensity (Isshiki, 1965; Isshiki and Von Leden, 1964; Yanagihara and Koike, 1967). The vibrations of the vocal cords determines the mean air flow rate. Thus the study of mean air flow rate would indirectly reflect the functioning of the laryngeal system.

Iwata and Von Laden (1970) recommended the use of the phonation quotient as an indicator of air usage when mean flow rate cannot be directly determined. Hiraao, Koike, and Von Laden (1968) have reported a significant correlation between phonation quotient and mean flow rate in normal adult subjects. The results of present study support the findings of Hirano, Koike and Von Leden (1968) i.e, both the estimated phonation quotient and mean air flow rate and obtained phonation quotient and mean air flow rate have shown high positive correlation.

Results of the present study also confirms the reports of Ran and Beckett (1984) that the mesa flow rate can be estimated from the vital capacity sad the maximum phonation duration. Based on these, Rau and Beckett (1984) states "speech clinicians who wish to apply the approach developed in this study may use a stopwatch and an inexpensive, compact spirometer to measure vital capacity and maximum phonation duration. These two measures allow for a phonation quotient to be calculated and then adjusted by means of the reported equation to estimate mean flow rate.

The desirable features of portability and economy of voice instrumentation were with the three spirometers used in this study. The instruments say be carried ear moved about easily within any clinical setting, as they are battery or manually operated. They are equipped with disposable mouth pieces and compact carrying Cases.

Based on these considerations, we suggest that the need for increased utilization of instrumentation for screening of vocal function can be relieved through the use of inexpensive spirometers. By deriving a phonation quotient, clinicians can estimate mean flow rates for their patients to determine if more extensive assessment is required, and if referral is indicated.

We might also note that the estimated mean flow rate method reported here has been used repeatedly within the voice clinic at our university with excellent clinical results, in both diagnosis and therapy. Our clinical impression over recent months has been that the calculated values closely match mean flow rate values obtained by more precise and conventional instrumentation.

Studies are needed to provide simple and accurate estimated values for children."

Thus they have found this method of estimating mean flow rate as an useful clinical fool and recommended further studies to "provide simple and accurate estimated values" for children. The present study attempted to further simplify the method of estimating mean flow rat* by using height and weight of an individual to estimate the vital capacity instead of an instrument like spirometer or expirograph to assess the vital capacity. Results of the present study are consistently indicated that there is no significant difference between the estimated and obtained vital capacities and mean airflow rates. Thus a simpler method of estimating mean flow rate has been developed. This method requires only a weighing machine, a measuring tape, and a stopwatch to assess mean flew rate. It is hope that this method can be used to get reliable and valid mean air flow rate values in clinical population as done by the previous investigators (Ram and Beckett, 1984).

SUMMARY AND CONCLUSIONS

The measurement of all flow has gained importance in recent years in screening, assessing, and treating voice disorders (Rau and Beckett, 1984).

The study was conducted to findout the possibilities of I. Predicting vital capacity based on height and weight of an individual; and II. to predict mean air flow rate based on vital capacity and maximum phonation duration and to validate the methods.

The experiment was carried out is two parts. In Part 1, 30 normal males, age ranging from 18 to 29, with a mean age of 21.47 years, and 30 normal females, age ranging from 17 to 22, with a mean age of 20.8 years served as subjects. The vital capacity were determined using expirograph. Based on their height and weight, and vital capacity measured a 'nomogram' was constructed for males and females separately.

The maximum phonation duration was measured for each subject. Based on maximum phonation duration and vital capacity, the phonation quotient was calculated fog each individual. Then mean air flow rate for each subject was calculated using the formula $\text{MFR} = \frac{\text{Phonation volume}}{\text{Phonation time}}$.

Further the mean air flow rate was also determined for each subject using the formula (MPR = 77 + .236 PQ) given by Rau and Beckett (1984) for both males and females. The estimated and obtained mean airflow rates were compared.

In part II of the experiment, 15 males age ranging from 19.5 to 30, with a mean age of 23.43 years, and 15 females age ranging from 18 to 24, with a mean age of 19.67 years served as subjects.

Based cm the height and weight, the vital capacity was predicted fox each subject (using nomograns derived in part I of the experiment). Than correlation coefficients were found out between VC estimated and obtained for males and females separately, further the phonation quotients were predicted based on the vital capacity (estimated) and maximum phonation duration (measured) for all the 30 subjects. The mean airflow rate was alao estimated using the formula MFR = 77 + .236 PQ (which was indicated as mean flow rate estimated).

Then the vital capacity and mean airflow rates were determined for all the subjects using routine procedure (i.e. using expirograph) (which were indicated as vital capacity obtained and mean airflow rate obtained).

The phonation quotients were calculated using vital capacity (obtained) and maximum phonation duration. The phonation quotients (estimated and obtained) were compared for each subject.

The mean flow rates (obtained) were compared with the mean flow rates (estimated) for all the subjects. Then correlation coefficients were found eat between phonation quotient and mean air flow rate (estimated and obtained). The results indicated that there was no significant difference between vital capacity estimated and obtained for both males and females. There was also a high positive correlation between the estimated and obtained PQ and MFRs. These results indicate that the vital capacity can be predicted baaed on height and weight of an individual, and it is possible to predict mean air flow rate based on vital capacity (estimated) and maximum phonation duration.

RECOMMENDATIONS:

/1/ Using same method the study can be carried out on larger population.

/2/ This study can be repeated with different age groups.

/3/ This study can be carried cut on clinical population to find out the clinical utility of the method.

BIBLIOGRAPHY

Aikin, W.A., : The separate functions of different parts of the rima glottidis, J.of Anatomy and Physiology, 16, 1902, 253-256.

Amerman, J.D., and Williams, D.K.: Implications of respirometric evaluation for diagnosis and management of vocal fold pathologies, Brit. J.Dia.Comm.l4(2), 1979, 153-160.

Arnold, G.E.: Physiology and pathology of the cricothyroid muscle, Laryngoscope, 71, 687-753, 1961.

Bastian, H.J., Unger, E., and sasama, R: Pneumotachographic objectification of therapeutic processes and results. Folia phoniat, 33(4), 1981, 216-226.

Beckett, R.L. (1971): The respirometer as a diagnostic and clinical tool in the speech clinic, J.Sp.Hear, Dis. 36, 235-240.

Berry, M.F., andEisenson, J. : speech disorders, Appleton-Century-Crofts, Hew York, 1956.

Bhatia, S.L: The vital capacity of the lungs, Ind.Med.Gaz. 64, 519, 1929

Bhattacharya, D.K: vital capacity of the Jat males of Punjab. Modification of the formula existing faith computation. Indian J.of Med.Res. 51 : 2, 1963.

Boone, D.E : The voice and voice therapy (2nd Ed), Prentice-Hall, Englewood Cliffs, 1977.

Boone, D.E. : The voice and voice therapy (3rd Ed). Prentice-Hall, Inc, Englewood Cliffs, N.J. 1983.

Bouhuys, A., Proctor, D.F., and Mead, J.,: Kinetic aspects of singing, J.Appl.Physiol. 21, 483-496, 1966.

Brackett, I.P: Parameters of voice quality, in Handbook of Speech pathology and Audiology (Ed.by Travis) Appleton-Century-Crofts, New York, 1971, p.441.

Brodnitz, F.s.,;Vocal Rehabilitation, Rochester, Minn: Whiting Press, 1959.

Curtis, J.F(Ed): Processes and disorders of human communication. New York: Harper and Row,Publ. 1978.

Damste, P.H., Hollein, H., Moore, P., and Murphy, T: An X-ray study of vocal fold Length, Folia Phoniatr. 20, 349-359, 1968.

Darby, J.K(Ed): Speech evaluation in Medicine, Grune and Stratton, Inc, 111, fifth Avenue, New York. (1981).

De, P, and De, B.N: The vital capacity of the Bengalis, Ind.Med. Gaz. 75, 409-1939.

Erickson, D and Atkinson, J.E.: Speechproduction - in N.J.Lass, Leija, V. McReynolds, Jerry, L Northern and David, E, Yoder (Ed): Speech and Hearing: Volume-1 (1982) W.B. Saunders Co. West Washington square, Philadelphia, Pa 19105.

Faaborg-Andersen, K:Eleetromyogrsphic investigation of intrinsic laryngeal muscles in humans, Actaphysiol. Scand, 41: Suppl. 140, 1957.

Fairbanks, G., Voice and articulation drill book (2nd ed). New York, Harper and Row, 1960

. Fant, G: Acoustic theory of speech production(1960) The Hague, Monton.

Fant, G: Preliminaries to analysis of the human voice source, Q.Prog.status Rep., Speech Transm, Lab., R.Inst. Technol.Stockh,No.4, pp.1-27 (1982).

Ferrein, A, De la formation de la voix de I' homme. Hist. Acad. roy. Soc., 1741, 409-432.

Fletcher, H: Speech and Hearing in communication, D.Van Kostrand Co., Inc, 1958.

Fletcher, Wm.w., A study of internal laryngeal activity in relation to vocal intensity, Ph.D. Diss, Northwestern, University, 1950.

Fransworth,D.W.: High-speech motion pictures of the vocal cords, Bell Lab. Record, 18, 1940, 203-208.

Gay, T., strome, M., Hiroae, H., and Sawashima, M: Electromyography of the intrinoic laryngeal muscles during phonation Ann.Otol.Rhinol.Laryngol. 81: 401-409, 1972.

Goldman, M.D., and Mead, J: Mechanical interaction between the diaphragm, and Rib cage, J.Appl. Physiol. 35: 197—204, 1973.

Gordon, M.T., Morton, F.M., Simpson, I.C (1978): Airflow measurements in diagnosis assessment and treatment of mechanic dysphonia. Folia Phoniat, 30, 161-174.

Gould, J., Okamura, H., static lung volumes in singers. Annals of Otolaryngology, Rhinoplasty, and Laryngology, 82, 1973, p.89.

Hippel, K., and Mrowinski, D., Examination of patients with normal and abnormal voice by pneumotachography, HNo.26(12), 1978, 421-423.

Hirano, M., Clinical examination of voice, Springer-verlag/Wein, Mew York, 1981.

Hirano, M., Koike,Y and Von Leden, H,(1968), Maximum phonation time and air usage during phonation. Folia Phoniat. 20, 185-201.

Hi rote, I, Hirano, M, Toyozumi, Y., and Shin, E: Electromyographic investigation of the intrinsic laryngeal muscles related to speech sounds. Ann.Otol.Rhinol. Laryngol. 76, 861-872, 1967.

Hollies, H: Vocal pitch variation related to changes in vocal fold length, J.Speech Hear, Res., 3: 150-156, 1960.

Hollien, H., and Moore, P: Measurements of the vocal folds during changes in pitch, J•Speech Hear. Res. 3, 157—165, 1960.

Husson, R: Erude des phenomenes physiologlgues et acoustiques fondamentaux de la voix chantee. Thesis, Paris, 1950

Isshlki, N.,: Regulatory mechanism of the pitch and volume of voice, Otorhinolaryngology Clinic, Kyoto, 52, 1959, 1065.

. Isshiki, N: Regulatory mechanism of vocal intensity variation, J.Sp-Hear.Res. 7, 17-29(1964).

Isshiki, N: Vocal intensity and airflow rate. Folia phoniatrica, 17, 92-104(1965).

Isshiki, N: Remarks on mechanism for vocal intensity variation, J. Speech Hear.Res. 12: 665-672, (1969).

Isshiki, N: and Von Leden, H: Hoarseneast Aerodynamic studies. Archieves of Otolaryngology, 80, 206-213 (1964).

Iwata, S., Esaki, T., Iwami, K., and Takasu, T: Laryngeal function in patients with laryngeal polyps after laryngomicrosurgery (Japanese Text), Pract.Otol.Kyoto, 69(6), 1976, 499-506.

Iwata, S, and Von Leden, H(1970): Phonation quotient in patients with laryngeal diseases. Folia Phoniatrica, 22, 117-128.

Iwata, S., Von Leden, H(1970a): Clinical evaluation of vocal velocity index in laryngeal disease. Ann.Otol. Rhinol.Laryngol. 79, 259-268.

Iwata, s., von Leden, H., and Williams, D: Airflow measurements during phonation,J,Comm. Disord. 5(1), 1972, 67-69.

Jain, S.K., and Gupta, C.R.; Age, height and body weight as determinants of ventilatory norms in healthy men above forty years age, Ind.J.Med.Res. 55, 599-611, 1967a.

Jain. S.K., and Gupta, C.R.:Lung function studies in healthy men and women over forty, Ind.J.Med. Res.55, 612-619, 1967b.

Jain, S.K., and Ramaiah, T.J., Spirometric studies in healthy women 15-40 years age, Ind.J.Chest Dig. 9, 1-12, 1967a.

Jain, S.K., and Ramaiah, T.J., Influence of age,height and body surface area on lung function healthy women 15-40, years old. Ind. J.Chest. Dis, 9, 13,

Jain,S.K.,and Ramaiah,T.J.,:Lung volume and machines of breathing in healthy boys, 7-14 years old, Ind. J. Chest Dis. 10, 63-66, 1968a.

Jain,S.K.,and Ramaiah,T.J.,Prediction of ventilatory 'norms' in healthy boys 7—14 years age. Ind. J.Chest Dis. 10, 69-79, 1968b.

Jain, S.K., and Raraaiah, T.J., Normal standards of pulmonary function tests for healthy, Indian men 15—40 years old. comparison of different regression equations (prediction formulae), Ind. J.Med.Res. 57: 1453-1466, 1969.

Jayaram, K.,: An attempt at an objective method for differential diagnosis of dysphonias, M.Sc., Dissertation, 1975,

Judson, S.V.and Weaver, A.T.: Voice Science, Appleton-Century-crofts. New York, 1965.

Kelman, A.W., Gordon, K.T., Simpson, I.C. and Morton, F.M., Assessment of vocal function by airflow measurements. Folia phoniatrica, 27: 250-262 (1975).

Krishnan, B.T., and Vareed, C, The vital capacity of 103 male medical students in south India. Indian J.of Medical Research, Vol.19, 4, April, 1932, 1165-1183.

Kunze, L.E: Evaluation ofmethods of estimating subglottal air pressure, J.SP.Hear.Res.7, 151-164 (1964).

Ladeforged,P and McKinney, N.P., Loudness, sound pressure, and subglottal pressure in speech, JASA, 35, 1963, 454-460.

Liskovievs, K.F., Physiologie der menschlichen stimme, Leipzig, 1846.

Mandi, A, Lengyal, E., and Csukas, M: Evaluation of respiratory function tests. Aged persons abstracted in excerp. Med.Che.Dis. 30. 1, 1976.

McGlone, R.E., Air flow during vocal fry phonation, J.Speech Hear. Res, 10(2), 1967, 299-304.

McHenry, M.A., and Reich, A.R. : Effective airway resistance and vocal sound pressure level in cheerleaders with a history ofdysphonic episodies. Folia, Phoniat. 37, 223-231, 1935.

Mead, J., Bouhuys, A., and Proctor, D: Mechanisms generating sub-glottal pressure, In Bouhuys, A(Ed), Sound production in man, Ann. N.Y. Acad. Sci. 155, 177-181, 1968.

Meenakshi, S, "Spirometric data in south Indian subjects, 60 to 80 years of age". Indian J.of physiology and Pharmacology Vol.28, No.1, 1984 (58-62).

MerKel, C.L., Der Kahlkopb . Leipzig, 1873.

Michel, J.F., and wendahl, R., Correlates of voice production, In Hand book of Speech Pathology and Audiology (Ed. by Travis) Appleton-Century-Crofts, New York, 1971.

Milledge, J.S.,Vital capacity and forced expiratory volume one second in south Indian men, Ind. J.Chest. Dis. 7, 97, 1965.

Mukherjee, H.N., and Gupta, P.C. The basal metabolism of Indians (Bengalis), Ind. J.Med.Res.18, 807-1931.

Nag, S.K., Chatterjee, s., and Dey, S.K., Influence of long term cigarette smoking on ventilatory measurements of Calcutta people, IJPFAZ, 26(5), 1982, p.34.

Nataraja, N.P.. and Jayaram, M., A new approach to the classification of voice disorders, J.of All India Inst. of Sp. and Hear. 8, 1982, 21-28.

Negus, U.E., The mechanism of the larynx St.Louis: C.V.Mosby Co. 1929.

Pressman, J., Physiology of the vocal cords,in phonation and respiration, Arch.Otolaryngol, 35,1942, 355-398.

Pressman, J., and Keleman, G.,Physiology of the larynx, Physiological reviews, 35, 1955, 506-554.

Ptacek, P and Sander,B.K. Maximum duration of phonation, J.Sp. Hear.Dis., vol. 28 (1963a), 171-182.

Ran, D., and Beckett, R.L. (1984), Aerodynamic assessment of vocal function using hand held spirometere, J.of Sp. and Hearing, Disorders, 49, 183-188.

Reddy, D.U.S., and Sastry, P.B. studies in vital capacity, Ind.J. J.Med.Res. 32, 237, 1944.

Sawashima, M (1966): Measurement of maximum phonation time, JPN. J.Logoped. Phoniat, 7, 23-28.

Schidt, C.D., Dickman, M.L., and Gardner, R.M., Spirometric standards for healthy elderly men and women. Am. Rev. Resp. Dis. 108, 933-939, 1973.

Schneider, P; and Baken,R.J., Influence of lung volume on the air flow intensity relationship, JSHR, 27, 1984, 430, 435.

Shashikala, Physloacoustic economy at optimum frequency. A dissertation submitted in part fulfilment for the degree of Master of science for (sp. & Hg), Univ. of Mysore, 1979.

Sheela, A Comparative study of vocal parameters of trained and untrained singers. M.Sc., Dissertation 1974, Mysore University.

Shigomori, Y.(1977): some tests related to the air usage during phonation. Clinical investigations. Otologica, (Pukuoka) 23, 138-166.

Sonninen, A: I: the length of the vocal cords the same at the different levels of singing? Acta Otolaryngol. (Suppl), 118, 219-231, 1954.

Talang, D.M., and Bhagwat,G.A., studies in the vital capacity of Bombay Medical Students, Ind.Med.Res.29, 793, 1941.

Timcke, R.H., Von Leden, and Moore, P: Laryngeal vibrations: measurements of the glottic wave Part-1. The normal vibratory cycle. Arch Otolaryngol. 68, 1958, 1-19.

Travis, E.L(Ed) Handbook of Speech Pathology and Audiology, Prentice Hall Inc, Englewood Cliffs, N.a. 1957.

Van dan Berg, J., Direct and indirect determination of mean subglottic pressure* Folia Phonatrica, 8, 1956, 1-24.

Van den Berg, J., Subglottic pressure and vibrations of the vocal folds. Folia phoniat. 9, 1957, 65-71.

Van Den Berg, J., Myoelastic aerodynamic theory of voice production, J.of Speech and Hear.Res. Vol.1, No.3, (1958), 227-244.

Van Riper, C, speech Correction: principles and methods (3rd ed), Prentice-Hall, NewYork, 1954.

Verma, S.s., Nanda Kishore, Raman, C.v., Lakhera, S.c., and Dass, S.K., Prediction of some ventilatory normas in healthy Indian males 21-69 years of age, IJPPAZ, 17(1), 1983, P.45-49.

Von Leden, H: The mechanism of phonation, Arch.of Otolaryngol. 74, 1961B, 660-676.

Wilson, D.K., Voice problems of children, 2nd ed. (Williams and Wiikins, Baltimore, 1979). \ '

Wallatein, H: Der Bewegungsvorjana und den stimmlippen warend der atimmgebung. Arch.fur ohren-nasen-und kehlkopfheilkunde, 1942, 1936, 124.

Yanagihara, N and Koike, Y., The regulation of sustained phonation. Folia phoniatrica, 19, 1-18, (1967).

Yanagihara, N., Koike, Y., and Von Leden, H (1966), Phonation and respiration:Function innormal subjects. Folia, Phoniatrica, 18, 323-340.

Yoshioka, H., Sawashima, M., Hirose, H., Ushijima, T., Honda, K. (1977), Clinical evaluation of air usage during phonation, Jpn.J.Logoped Phoniat, 18,87-93.

Zemlin, R.Z., Speech and Hearing Science: Anatomy and Physiology (2nd ed) (1981), Prentice-Hall, Inc, Englewood Cliffs, New Jersery, 07632.

zipursky, M.A., Fishbein, B.M., Thompson, G., Ezerzer, F., and Epstein, S.W., Aerodynamic testing in psychogenic voice disorders respiratory and phonatory studies, Hum.Commun.Can.1983, Mar.7(2), 69-73.