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Title: A COMPARISON OF A SMOKING AND NONSMOKING POPULATION USING THE FORCED EXPIRATORY FLOW IN THE SEVENTY-FIVE TO EIGHTY-FIVE PERCENT SEGMENT OF THE SPIROMETRIC CURVE

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Forced vital capacity lung expiration examinations of nonsmoking and cigarette-smoking male sample populations were compared to determine if the 75 to 85 percent segment was a more sensitive test of early lung dysfunction. The nonsmoking population was composed of 240 men who were tested for values of forced vital capacity and forced expiratory flow 25 to 75 percent. Of this original group, 213 were evaluated for forced expiratory flow 75 to 85 percent. The smoking population contained 75 healthy men who had a history of consuming ten or more cigarettes per day for at least ten years. All participants were between the ages of 30 and 49. Nine-liter Stead-Wells spirometers with a plastic bell were used to measure lung capacity. Differences between the populations were determined by

using linear analysis of covariance. Predictive regression equations were formulated for nonsmokers and smokers for FVC, $FEF_{25-75\%}$ and $FEF_{75-85\%}$.

The primary significant difference between the nonsmokers and smokers was found in the forced expiratory capacity flow rates farthest from total lung capacity ($FEF_{75-85\%}$). Flow rates for the middle half of the spirogram ($FEF_{25-75\%}$) were not significantly different for these two populations. Neither was there a difference for the forced vital capacity (FVC). In general, two other tests were found significant for only the $FEF_{75-85\%}$. First, smokers with any symptoms of pulmonary damage as defined through the Emphysema Screening and Research Center questionnaire averaged significantly lower spirogram values. Secondly, the more years an individual smoked (minimum of ten cigarettes per day) the lower his test score.

A Comparison of a Smoking and Nonsmoking Population Using the Forced Expiratory Flow in the Seventy-five to Eighty-five Percent Segment of the Spirometric Curve

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DEDICATION

This thesis is dedicated to biologist Ellis Wyatt, student and teacher, who by example and encouragement leads students to the enjoyment of Science.

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A COMPARISON OF A SMOKING AND NONSMOKING POPULATION USING THE FORCED EXPIRATORY FLOW IN THE SEVENTY-FIVE TO EIGHTY-FIVE PERCENT SEGMENT OF THE SPIROMETRIC CURVE

CHAPTER I

INTRODUCTION

The Surgeon General's 1964 report on smoking stressed the importance of cigarette smoking as a causative factor in pulmonary diseases (30). For the nonsmoker with no pulmonary disease, research does not totally agree as to when lung function decreases biologically. Sometime after 25 years of age full growth has been reached and there is a constant linear decline in the lung function (23, 26). The damage done by cigarette smoking apparently starts in the small airways (7, 10, 18). Destruction in these small passages is progressive. Once the damage starts, the adjacent airways are affected by the disease until multiple airways become nonfunctional for air exchange. Eventually, the larger bronchioles are involved. Hogg and others have found that once extensive destruction has spread to the larger airways, the damage appears to be irreversible (10).

Spirometers are one of the common instruments used for measuring the ventilatory function in both screening programs and individual clinical case studies (23). Spirometry correlates age, sex and height of an individual (15). Nomograms have been standardized, relating these anatomic factors to lung expiratory ability for non-smoking adults. Such standards are now substantiated in research (23). The test is reliable and simple to perform and evaluate. Individual test-retest spirometric calculations of nonsmokers are at best tentative. This is because the normal distribution between the actual and estimated values in tested samples for most spirometric calculations has been quite large (15, 23). These large variables make detection of abnormalities and lung diseases tenuous (7, 8, 23).

In recent years awareness within the lay public and medical professions concerning the dramatic rise of chronic obstructive pulmonary disease has increased the development of many instruments which measure lung function. There are some research techniques more sophisticated than spirometry (21). One of these techniques is to fully inspire oxygen from a spirometer and expire into a "bag box" (3, p. 747). The gas is sampled at the mouthpiece, using a rapidly responding nitrogen analyzer. Near the residual volume the concentration of nitrogen sampled rises abruptly and is termed closing volume (3). The use of closing volume as an examination is under some controversy, but it is a pragmatic test to detect early peripheral airway disease (3).

Plethysmograph instruments are also widely used in research (5, 7, 8, 10). In 1956, DuBosis was the first to use this method (5). When a subject is totally enclosed in a body plethysmograph, reduction of the alveolar pressure during inspiration causes a proportional increase in pressure in the plethysmograph. This occurs because the number of gas molecules in the plethysmograph remains constant. Fewer molecules within the chest causes compression of gas molecules outside the chest. By measuring changes in the plethysmograph pressure, calculations concerning alveolar pressure can be made. A special tube positioned at the individual's mouth will show the relationship between the pressure changes. These sophisticated instruments utilized in conjunction with anatomic research have shown that forced vital capacity measured farthest from total lung capacity may represent small airway lung volume (8, 10).

Spirometry has also been used to measure the flow rate farthest from total lung capacity (7). The forced vital capacity maneuver can be divided into several time-volume segments. The first 25 percent of the expired air is dependent on individual effort; the same is true of the last 10 to 15 percent. The air flow between these two segments is effort independent. The average rate of flow for almost any specified portion of this effort-independent part can be measured. A test which would be most useful would include the rate of flow for the small airways. Such passages contribute only about 20 to 30 percent of the resistance measured by the forced vital capacity (FVC) tests (20). Twenty to 30 percent is within the range of normal variability for spirogram evaluations. The middle half of the spirometric curve, a current test, may include small lung airways but may not be as sensitive an examination as one measuring lower lung flow percentages. In one study, by Gelb (7), people who were thought to have diseased small airways showed a much better predictability in the spirometric forced expiratory flow at the 80 percent point of the air expulsion from their lungs. The forced expiratory flow 75 to 85 percent for a large sample population of nonsmokers has not been compared to a smoking population of the same age, sex and height. A test of this nature could show whether there is any value in this lung function test as a spirometric screening program or case study.

Purpose of the Study

The purpose of this study was to detect if there was a statistical difference in the forced vital capacity (FVC) at low lung volumes between smoking and nonsmoking populations. The FVC for both populations will be categorized into four segments: the forced capacity (FVC), the forced expiratory flow 75 to 85 percent ($FEF_{75-85\%}$), the forced expiratory flow 25 to 75 percent ($FEF_{25-75\%}$) and the forced expiratory volume in one second (FEV_1). The independent variables will be sex, age, height and smoking longevity. Participants in the study will be asymptomatic for conditions known to inhibit ventilatory function such as lung disease or chest injury.

Hypothesis

H_0: The hypothesis of this study is that there will be no difference in the $FEF_{75-85\%}$ segment of the spirometric curve scores of the smoking and nonsmoking sample populations.

H_1: The $FEF_{75-85\%}$ segment of the spirometric curve scores will be lower statistically in the smoking sample population.

The statistical procedure in this study is to use analysis of variance. The population scores will be tested for significance at the 0.01 and 0.05 levels.

Definition of Terms

Terms frequently used throughout this study are thus defined.

acute bronchitis--an inflammation of the bronchial tubes accompanied by sudden onset and severe symptoms.

bronchial muscular spasm--a spasmodic narrowing of the bronchial tubes.

bronchioles -- minute (less than 2 mm in diameter) bronchial tubes.

chronic bronchitis--a long-continued inflammation of the bronchial tubes characterized by attacks of coughing, by expectoration and by secondary changes in lung tissue.

chronic obstructive pulmonary disease (COPD)--a group of diseases in which chronic bronchitis, asthma or anatomic emphysema are included (22).

correlation coefficient (R)--a measure which expresses the extent to which multiple variables are related.

current cigarette smoker--an individual who regularly smokes; has smoked for at least ten years; or, if having quit smoking, did still smoke six months ago.

emphysema--a structural disease characterized by distention of air sacs, causing a loss of normal elasticity of lung substance. The air spaces distal to the terminal bronchioles enlarge, and the alveolar walls are destroyed (22).

etiology--the study or theory of the cause of any disease or condition and all the knowledge regarding such cause.

expiratory muscles--the abdominal and intercostal muscles which are responsible for the expulsion of air in breathing.

ex-smoker--an individual who once smoked cigarettes regularly but has not smoked within the last six months. Six months is an arbitrary point in time when many of the immediate and temporary physiological effects of smoking are no longer evident (20).

forced expiratory flow 25 to 75% ($FEF_{25-75\%}$)--the average rate of flow per second of the middle half of the spirogram curve.

forced expiratory flow 75 to 85% ($FEF_{75-85\%}$)--the average rate per second of flow between the 75 to 85% segment of the forced vital capacity.

forced expiratory volume on one second (FEV_1)--the volume of air exhaled during the performance of a forced vital capacity.

forced vital capacity (FVC)--a volume of gas expired after full inspiration, expiration being as rapid and complete as possible.

heavy smoker--a cigarette smoker who smokes 21 or more cigarettes per day.

homeostatic mechanisms of the lung--any morphologic system in the body which tends to stabilize the internal environment of the lungs. This would include the nervous and circulatory systems as well as mucus and cilia and the muscle lining of the bronchioles.

intrapulmonary events--a physical change within the substance of the lungs relating to lung elastic recoil and airway caliber and taking place during breathing function.

intrinsic airway disease--any diseases situated entirely within the airways and pertaining only to the lungs.

kymograph--an instrument attached to the spirometer for making a permanent record of the forced vital capacity on special chart paper.

localized lesion--any pathological or traumatic discontinuity of tissue giving origin to distinctive local symptoms.

lung function--all of the structural adaptations that produce the bellows effect,which enables air to enter the trachea and bronchi, pass through the bronchioles to the respiratory alveolar ducts and alveolus, and return again to the external environment.

maximal voluntary ventilation--a volume of air which a subject can breathe with voluntary maximal effort for a given time (22).

moderate smoker--a cigarette smoker who smokes from 10 to 20 cigarettes per day.

nomogram--a chart or diagram on which a number of variables are plotted, forming a computation chart for solutions of complex numerical formulas.

nonsmoker--an individual who has not smoked more than six months during his life (20).

peripheral bronchioles--terminal bronchioles which approximate 6 to 2 mm in diameter.

plethysmograph--an airtight instrument for recording various parts of the body or whole body size and/or blood supply.

pneumonia--a term for a group of lung diseases with many causative agents: bacteria, viruses, rickettsiae and fungi.

pneumoconiosis--a fibrous reaction in the lungs resulting from inhalation of dust. Some dust retained in the lungs is inert, thus causing no reaction; but a few dusts such as asbestos, silica, coal and beryllium, are known to cause a chronic reaction. The disease is diagnosed by the specific dust known to cause the reaction.

polluted atmosphere--any gas, liquid or solid found in the atmosphere which endangers life and health. For the purpose of this paper the only pollution considered will be respiratory pollutants: pulmonary irritants, dust, granuloma-producing agents, fever-producing agents and asphyxiants.

prediction formula--a mathematical calculation of linear regression equations through which one can predict an individual's performance from a sample of similar individuals.

pulmonary diseases--any of the multitudinous diseases pertaining to the lung.

regression equations--the general mathematical formulas ($V = a + bX$) which can be used to predict future scores based on tendencies revealed in previous studies of samples of similar individuals.

sarcoidosis--the general name for a group of diseases marked by nodula lesions.

secretion--the process of elaboration of a specific product from the goblet cells within the epithelium lining of the bronchus.

small airways--all bronchioles 2 mm or less in diameter.

sound health--all people in this study who marked a questionnaire that they had never had any of the following lung problems: 1) asthma, chronic bronchitis, emphysema, hay fever, heart trouble, pneumonia or tuberculosis; 2) chest injury or operation; 3) worked in a polluted atmosphere. In addition to these questions, the nonsmoking population answered that they had never had a persistent cough nor been treated recently for any respiratory condition. The members of the smoking population could be expected to admit to at least some of the symptoms relating to morning cough, protracted periods of cough and phlegm production, some dyspnea and wheeze. Individuals who for some other physical or mental reason could not perform a maximal effort on the spirometer were eliminated.

spirometer--an airtight instrument which is capable of inscribing a spirographic tracing of lung volume and time relations.

standard deviation--the square root of the sum of the squared deviations from the mean divided by the number of individual samples.

standard error of estimate (SEE)--the standard deviation of scores around the regression line.

total lung capacity (TLC)--an amount of gas contained in the lungs at the end of maximal inspiration.

thoracotomy--a surgical incision of the wall of the chest.

thoracic pressure--a pressure within the chest caused by the abdominal muscles which is either higher or lower than atmospheric pressure. Lower than atmospheric pressure causes inspiration, and higher than atmospheric pressure causes expiration.

vital capacity (VC)--a maximal amount of gas that can be expelled from the lungs following a maximal inspiration.

CHAPTER II

REVIEW OF LITERATURE

This review is directed toward the research of critical issues concerning small airway dysfunction resulting from cigarette smoking. The review will concentrate on pulmonary function ability, reduced lung capacity which results from cigarette smoking, and testing techniques and studies.

Pulmonary Ability and Reduced Lung Capacity

Cigarette smoking is one of the most important causes of chronic bronchitis and emphysema, the most common forms of chronic obstructive pulmonary disease (22). The major site of obstruction found in these diseases seems to be located peripherally in the small airways 2 mm or less in diameter (10). These irreversible conditions which produce an insufficient airflow are due to organic disease, not to a decreased elastic recoil or a "check-value" in the small bronchioles (10, p. 1359). During expiration the diameter of the bronchioles is decreased by two physical situations. First, the pressure to the chest cavity which causes air exchange is uniformly applied along the entire length both inside and outside of the air passages within the thoracic cavity. Second, there is no internal support of cartilage in the airways 2 mm or less in diameter. Whenever the interior pressure becomes lower than the exterior pressure, these structures are compressed and may collapse.

Usually airflow is high, 600 to 700 liters per minute. Some reversible factors which affect the airway diameter are the following conditions: 1) bronchiole muscular spasm, 2) mucosal edema, 3) acute bronchitis and 4) inflammation of airways (1). These reversible anatomic obstructions result in expiration requiring force from the expiratory muscles. The thoracic pressure outside the air passages becomes positive and the flow rate becomes measurably lower.

The irreversible destruction of the small airways is diffused throughout the lungs. Chronic bronchitis is thought to result from bronchiole mucosa edema, increased tone of the bronchial musculature and secretions. Chronic obstructive emphysema may be an extension of chronic bronchitis. This obstruction is a progressive disruption of the pulmonary structure, and subsequently, a lack of support for the smallest airways. There also is distortion, a narrowing and obliteration of the small airways which represents fixed obstruction of chronic lung disease (10).

For individuals free from pulmonary disease, the homeostatic mechanisms of the lungs do not change remarkably between ages 30 to 50 years (28). The effectiveness of the physiological processes that preserve internal uniformity decrease as a part of the aging process. Age does affect the components of the lung, especially the bellows and mechanical properties (28). Some researchers say that an aging individual will have a slow constant decrease in forced vital capacity from age 20 throughout his life (23, 28).

Ethnic race also affects the pulmonary lung function. Statistically significant differences have been found among white, black and Asian races in several FVC maneuver tests (26). Blacks and Asians had lower test scores, regardless of prevalence of chronic bronchitis or smoking history (26).

Body weight and the size of the chest cavity have been found to have little correlation to any spirometric measurements (15). Sex differences are significant because males tend to have a greater expiratory capacity, resulting in the development of definite prediction formulas for each sex (23). Other than age, height seems to have a positive relation to lung function measurements (15).

Testing Techniques

Spirometry is the simplest and most practical means of measuring respiratory volumes and flow rates (11, 22). The technique is performed by having the subject inspire to total lung capacity and then exhale as rapidly, completely and forcibly as possible. Expiration is made into an inverted, counterweighted, watersealed container with a pen arranged to record movement on a kymograph. Graphic fluctuation is recorded as a result of movement on a rotating kymograph on calibrated chart paper. This facilitates analysis of forced expiratory capacities. The container is bell-shaped, light-weight plastic that will hold nine liters of air.

Another recording device is an alcohol thermometer affixed to the intake air hole. The nine-liter Stead-Wells spirometer with plastic bell measures high frequencies of maximum volume and maximum expiratory flow rate more accurately than the nine-liter and 13.5 liter Collins metal bell spirometers (16). Subject position has been standardized in both the standing and sitting position with a nose clip to block escaping air. (6, 16)

There are some limitations to spirometry. Involuntary variation of maximal effort may result from low motivation, mood, health or nonpulmonary illness. Intrapulmonary events may not be reflected and measurements may not distinguish between normals and subjects with varying degrees of obstructive lung disease (11).

The internal physiological conditions are independent of the external environment and have stable magnitudes among normal individuals free from pulmonary disease. This applies to alveolar ventilation, oxygen and carbon dioxide tension, and the pH of arterial blood (19). There is a wide variability when the lung function flows are measured. Age, sex, height and race have been mentioned.

Some others include the following inconsistencies: 1) pulmonary history, 2) physical condition, 3) occupation, 4) lifestyle, 5) health and 6) muscular development of the chest.

Little is known about most of these other variables. There is a large disparity between the actual and estimated values of the forced vital capacity (FVC) test. Because there is this wide variability in estimated results in people, several kinds of tests have been proposed.

Basically, the FVC is but one test which quantifies the time rate of gas flow along the respiratory tree. The relationship of pressure to flow at a given lung volume is basic to interpulmonary dynamic volume tests. When lungs fill near total lung capacity, expiratory flow increases as pressure increases. Maximal expiratory flow near total lung capacity is highly dependent upon an individual's effort; whereas, maximum expiratory flow over the latter range of lung volumes requires less than a person's maximal effort and represents a limiting value that cannot be exceeded (11). As a result, the respiratory system is not limited by a subject's effort for the lower two-thirds of the FVC.

There are three general categories of test procedures of FVC. One group, qualified by instrument type, measures peak flow of gas during the first part of the FVC maneuver. Examples of peak flow are the percentage expired, qualified by time interval, or the maximal expiratory flow, qualified by volume measured and expressed as a percent of FVC.

Another test group measures volume of air exhaled after a specified time. Intervals from 0.5 second to 3.0 seconds have been used. One-second volume (FEV_1) is the most reliable interval. Peak volume in the first instant is not achieved, resulting in a problem of when to begin measuring the expiratory flow. Two hundred cubic centimeters has been arbitrarily selected as the point after which peak flow has been reached (11).

The third group of tests relates expiratory flow to lung volume. The mean expiratory flow during the FVC is commonly evaluated for lung abnormalities. The volume of air is exhaled over a specified volume range of the forced expiratory spirogram (FES). The $FEF_{25-75\%}$ and the $FEF_{75-85\%}$ are in the group which is used in this study.

Research Studies

Quantitative lung function testing procedures began in 1846 when John Hutchinson designed and built the spirometer (11). Hutchinson examined many subjects and measured and described vital capacity. Since that time many different techniques and descriptions have been tried. Most of these early studies did not produce adequate data from which prediction formulas and standard tables could be derived (15).

Usually either the standard error of estimate was large or a small sample number was used. Especially critical was the problem of establishing a "normal" subject.

One of the first research projects to address some of these problems was the 1961 "The Veterans Administration--Army Cooperative Study of Pulmonary Function" by Kory and Callahan (15). This study described a standard procedure for clinical spirometry. The precise techniques of calculating all aspects of lung dimensions were completely explained. The position and response of all individuals performing the tests was closely supervised. Nineteen parameters were measured for 468 men. Kory and Callahan considered the following normal: 1) no history of lung or heart damage; 2) a passing physical examination including an electrocardiogram and roentgenogram showing no chest disease; 3) mental understanding of the test; 4) physical ability to participate; 5) no disease which may limit muscular movement (15). Smoking history was not considered. Mean values, standard deviation and correlation coefficients were presented. Regression equations and a nomogram for vital capacity, forced expiratory volume for one-half second as well as one second were included. Many recent studies have used the nomograms and prediction formulas developed in this research.

The relationship of smoking to lung disease was evaluated in 1965 by Ferris, Anderson and Zickmantel (6). This etiology was only one segment of the larger Berlin, New Hampshire survey of chronic nonspecific respiratory diseases (6). The principle here was that "normal values can be developed for "normal people" (6, p. 252). There were 565 males and 654 females in this study. Prediction formulas for forced vital capacity, forced expiratory volume for one second and peak expiratory flow rates were derived.

Individuals were classified as either nonsmoking normal people or others with no obvious disease. Nonsmokers also included ex-smokers. Those without disease were people who smoked as well as people who did not smoke. In general, prediction values for the non-smoking group were found to be lower than the prediction values in the smoking group. There was no attempt to indicate the smoking habits of the population on which the nomograms were developed (6).

In 1971, Morris, Koski and Johnson (23) studied the spirometric values of lifetime nonsmokers. Predictive formulas were calculated using the data of 988 healthy nonsmoking men and women exposed to minimum air pollution. The variables were age and height. The predictive equations were compared to those formulated by other researchers, especially the work of Kory and Callahan in 1961 and Ferris and associates in 1965.

The $FEF_{25-75\%}$ was calculated in the lifetime nonsmoking study. Recently, Morris and associates have submitted for publication predictive formulas and nomograms for $FEF_{75-85\%}$ using the data from the 1971 study. In this study, pulmonary function scores and physical characteristics of the male lifetime nonsmokers between the ages of 30 and 49 years were analyzed and compared to the values of male smokers for $FEF_{25-75\%}$ and $FEF_{75-85\%}$. The results obtained by the Morris, Koski and Johnson (23) study will serve as a base line from which a comparison can be made using the smoking population gathered by this author.

The diagnosis of advanced chronic bronchitis or emphysema is usually not difficult to determine (20). Detection of minimal disease has proved arduous because obstruction to airflow is present in the small peripheral bronchioles. This is not easily measured by forced expiratory volume because these airways contribute only 20 to 30 percent of total resistance. In 1971, Gelb and his associates studied 14 patients to determine if a screening pulmonary function test could better detect disease than previously used screening examinations (7). The patients were randomly selected for screening from the Thoracic Surgical Service within one week before receiving a thoracotomy for a localized lesion. Before their operations, spirometric, plethmographic and blood gas tests were taken. The removed lung portion was classified as to extent of disease and the results compared to the screening tests. The research team classified three physiologic diagnoses. Seven of the patients had emphysema. Three had some intrinsic airway disease and four patients were found to have normal lungs (7).

The maximal expiratory flow-volume curves showed an interesting relationship among these classifications of patients. For the individuals found to have emphysema, the screening examinations showed only a slight reduction of airflow (57 to 90 percent of that predicted by Morris, Koski and Johnson's study). But these values were found only near total lung capacity when only 20 percent of vital capacity had been exhaled. At lung volumes at the 80 percent value of the vital capacity, these individuals were only 17 to 46 percent of predicted. The values for other routine pulmonary function studies, including VC, FEV_1 and TLC were normal or borderline abnormal (7). These same tests for the patients with normal lungs were no lower than 78 percent at high lung volume or 80 percent at low lung volume.

In 1973, Gelb and Zamel studied nine patients that had abnormal maximum expiratory flow volumes (8). All the patients had routine pulmonary function tests and chest roentgenograms. When special examinations associated with small airways were administered, the patients showed increased deviations. The maximum expiratory flow volume curves were abnormal most noticeably at low lung volumes, suggesting an alteration of the small airways (8).

Summary

Small airway disease may be measured by $FEF_{75-85\%}$. The recent studies by Gelb and by Morris suggest that additional research experience would separate normal from abnormal populations. This would indicate that there is a need to study young (30 to 49 years) male populations of cigarette smokers to determine if these people have abnormal predicted values at low lung volumes.

CHAPTER III

RESEARCH PROCEDURES

The research procedures were divided into three phases: analyzing data from a nonsmoking male population, testing and analyzing a sample of current cigarette smoking males, and treating the combined data statistically. The facilities and equipment of the Computer Center at Oregon State University were utilized in processing and computing the statistics.

Lifetime Nonsmokers

The nonsmoking population data were from "Spirometric Standards for Healthy Nonsmoking Adults," by Morris, Koski and Johnson (23). The subjects were predominantly members of either the Church of Jesus Christ of the Latter Day Saints or of the Seventh Day Adventist Church. No person in this group smoked cigarettes for a total period longer than six months. All individuals were screened by use of a questionnaire. Each subject gave a negative response to having had asthma, chronic bronchitis or pneumonia. They had never worked in an occupationally polluted atmosphere, had a chest injury or had a persistent cough. The population came from the Willamette River Valley north of Springfield and south of Portland, Oregon.

Of the 988 healthy, nonsmoking males and females, all 240 men between the ages of 30 and 49, inclusive, were used for spirometric values of the forced vital capacity (FVC) and forced expiratory flow 25 to 75% ($FEF_{25-75\%}$). Twenty-seven kymograph tracings were lost from the original study; therefore, 213 males were available for calculation of forced expiratory flow 75 to 85 percent ($FEF_{75-85\%}$).

Sampling Current Smokers

A total combined sample of 75 male cigarette smokers was obtained from the Emphysema Screening and Research Center of the Oregon Lung Association in Portland, Oregon and from the Veterans Administration Hospital, also in Portland, Oregon.

To be eligible for this study, each male had a smoking history of consuming ten or more cigarettes per day for at least ten years. Cough, sputum or phlegm production was not a factor for eliminating participants because of the variability in individual response to the irritations of tobacco smoke. However, healthy people could be disqualified if for some reason they had psychological barriers which precluded a maximal performance. Some men had an aversion to the activated dialdehyde disinfectant. Others simply could not perform in the clinical situation.

Approximately 50 individuals reporting into the screening center during a five-month period met the criteria for this study. The trained clinical investigator employed by the center administered the pulmonary function tests. The data were sent to Oregon State University.

The remaining data were collected at the Veterans Administration Hospital in Portland. Two hundred eleven male hospital employees between ages 30 and 49 were surveyed by personal letter two weeks prior to testing (Appendix B). Each letter explained the importance of the study and asked that the attached questionnaire be completed if the individual currently smoked cigarettes. In addition, Dr. Morris, Section Chief of Pulmonary and Infectious Diseases at the hospital, encouraged the staff members to participate (Appendix C). The majority of testing was done at the hospital during one week of December, 1973. A few individuals, unavailable in December, were tested at a later date.

Testing Procedures

The clinical testing procedures were developed by the Emphysema Screening and Research Center and the Veterans Administration Hospital. Kory and associates originally adapted this testing procedure in the classical study of veteran and army personnel (15). Each prospective participant received a one-page questionnaire to be completed prior to testing. All questions concerning the form were answered. The investigator then used the following procedures:

The individual's height and age were taken.

The individual was encouraged to breath normally until breathing was consistent. A nose clip was placed on his nose.

He was instructed to inspire as fully as possible and place his mouth over the mouthpiece.

The kymograph drum speed was changed to 1, 920 mm per minute. This maintained a one-second interval between parallel vertical time lines on the chart paper.

The subject blew out as rapidly and completely as possible into the mouthpiece.

Each test was done at least twice; however, a third test was completed if either of the first two obviously was invalid (23).

The drum on the spirogram was allowed to rotate at least more than one time prior to the next forced expiration. This prevented the curve tracings from overlapping and gave an ordered sequence for the tests.

The spirometer temperature was noted.

If the subject obviously misunderstood directions, the first tracing was ignored and the larger value of the latter two was analyzed. Every person was informed of his vital capacity and how it compared to the predictions developed by Morris, Koski and Johnson. Questions were answered concerning the relationship of smoking to pulmonary function and disease.

Analysis of the Spirogram

The purpose of this study was to determine if there was a statistical difference of the forced vital capacity at low lung volumes between a smoking and nonsmoking population. Selected pulmonary function tests not only measured flow rates near total expiratory capacity but also evaluated the forced vital capacity curve. The following four pulmonary function tests were utilized as measurements: forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), forced expiratory flow 25 to 75 percent ($FEF_{25-75\%}$) and forced expiratory flow 75 to 85 percent ($FEF_{75-85\%}$).

The effort selected for analysis was based on the highest single performance measured by the forced vital capacity and forced expiratory volume in one second. All other lung function recordings were taken from the selected performance of that FVC. Lung spirometric recordings were corrected to body temperature and pressure, saturated with water vapor (BTPS). The method of calculations was the same as that used in the study by Morris, Koski and Johnson (23) which had been modified from Kory and associates (15).

Forced Vital Capacity (FVC)

Forced vital capacity is the volume of gas expired after full inspiration, expiration being as rapid and complete as possible. The lowest inspiration point was subtracted from the highest peak on the tracing (Point A minus Point B on Figure 1, p. 28).

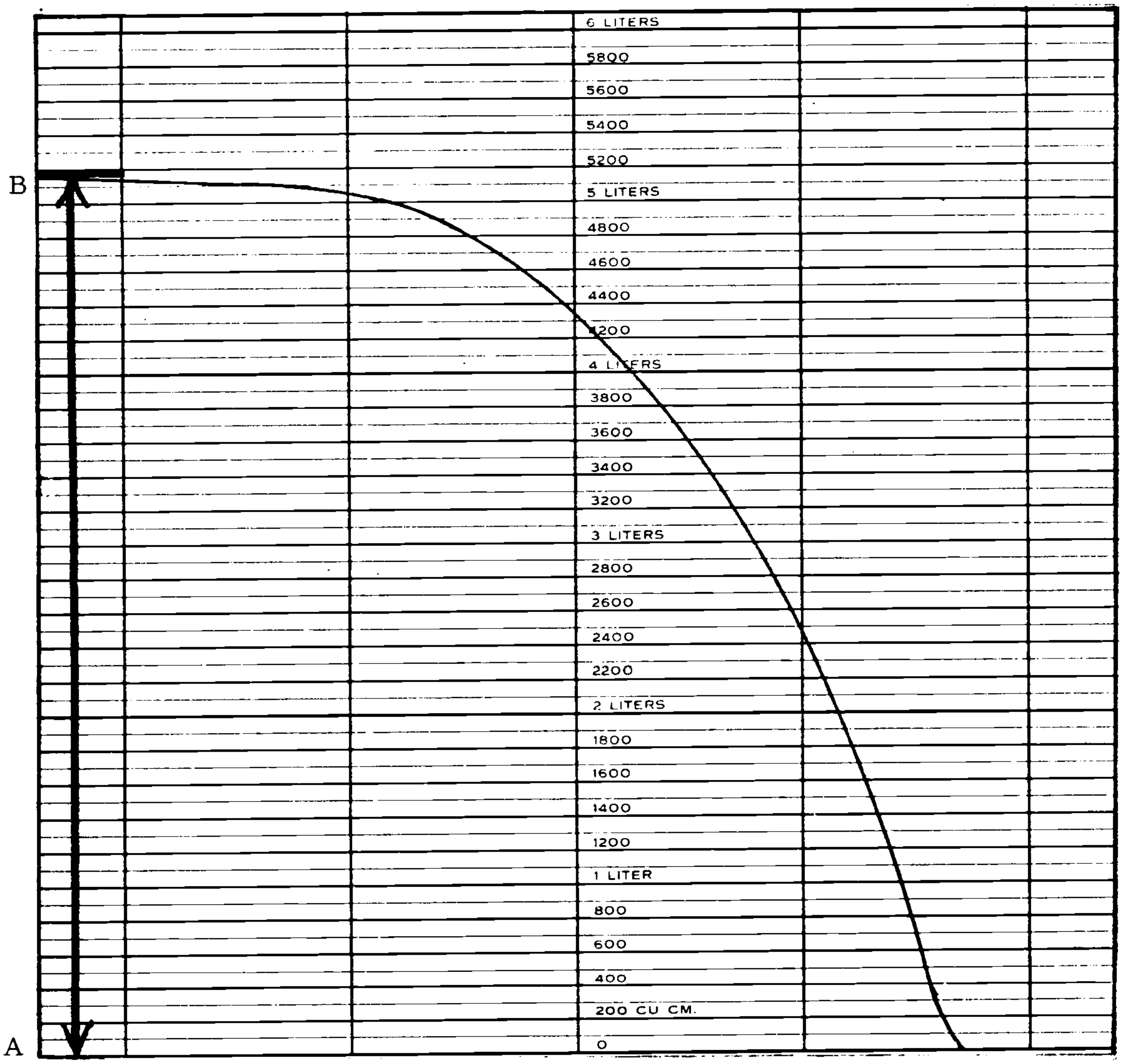

Figure 1. Forced vital capacity.

Forced Expiratory Volume in One Second (FEV_1)

The forced expiratory volume in one second is the volume of gas expired during the first one second of the forced expiratory capacity. An overlay marked in one-second time periods was placed upon the forced vital capacity curve. The established starting point was at 200 mm of expired air (Point C on Figure 2, p. 30). Two hundred millimeters is an arbitrary figure beyond which most researchers believe expiration is effort independent and no longer influenced by the diaphragm and intercostals (11). The base line value at 200 mm inspiration was subtracted from the volume expired found under the one-second overlay (Point D subtracted from Point E on Figure 2, p. 30).

Forced Expiratory Flow 25 to 75 percent ($FEF_{25-75\%}$)

This flow represents the average rate per second of the middle half of the spirogram curve. The value was found by dividing the total FVC into four equal volumes. On Figure 3 (p. 31), the spirogram for $FEF_{25-75\%}$ has been calculated. One-fourth volume was subtracted from the highest peak (Point F) and one-fourth was added to the lowest inspiration (Point G). A connecting line, drawn through these points, intersected two one-second lines on the kymograph

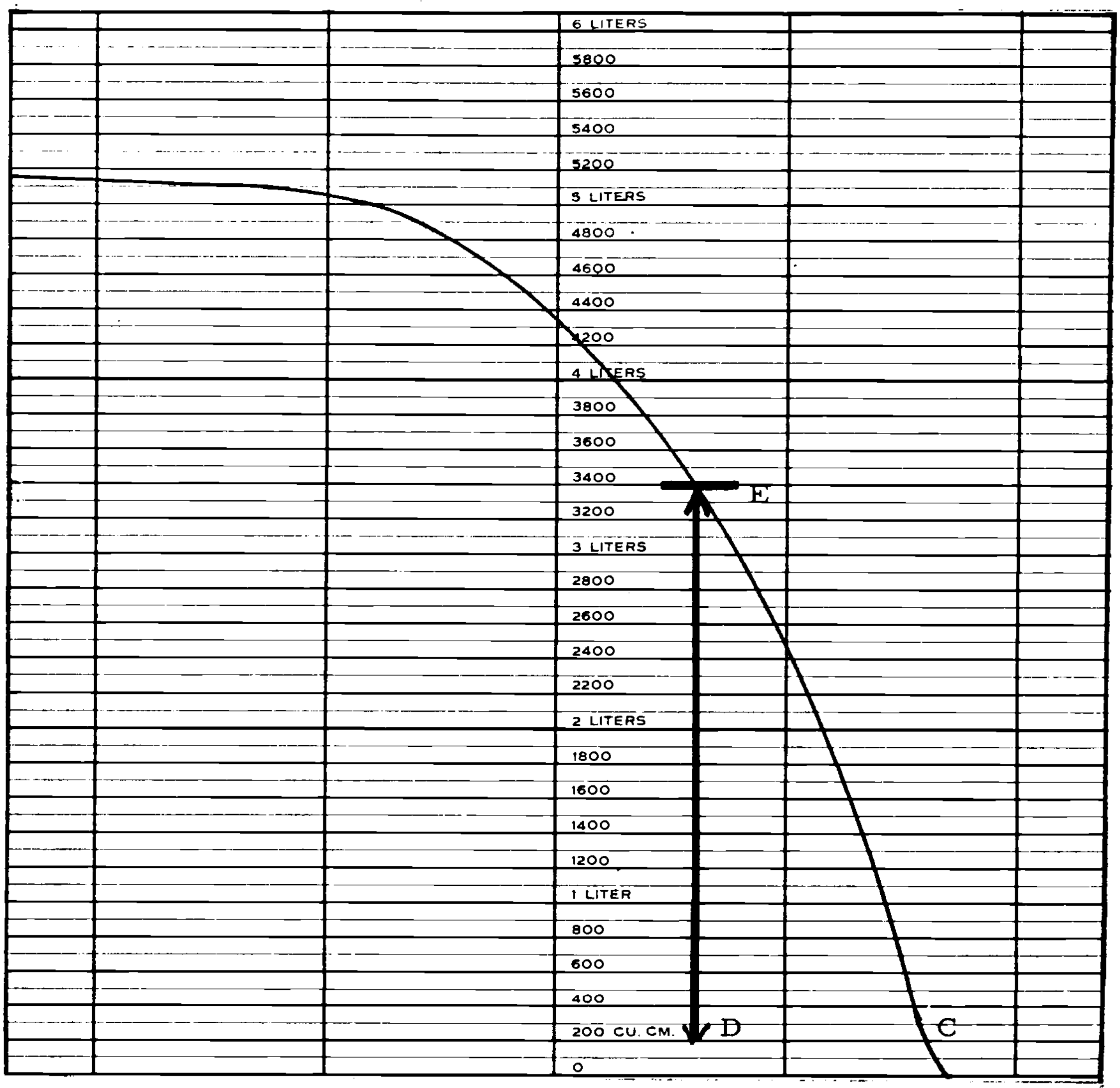

Figure 2. Forced expiratory volume in one second.

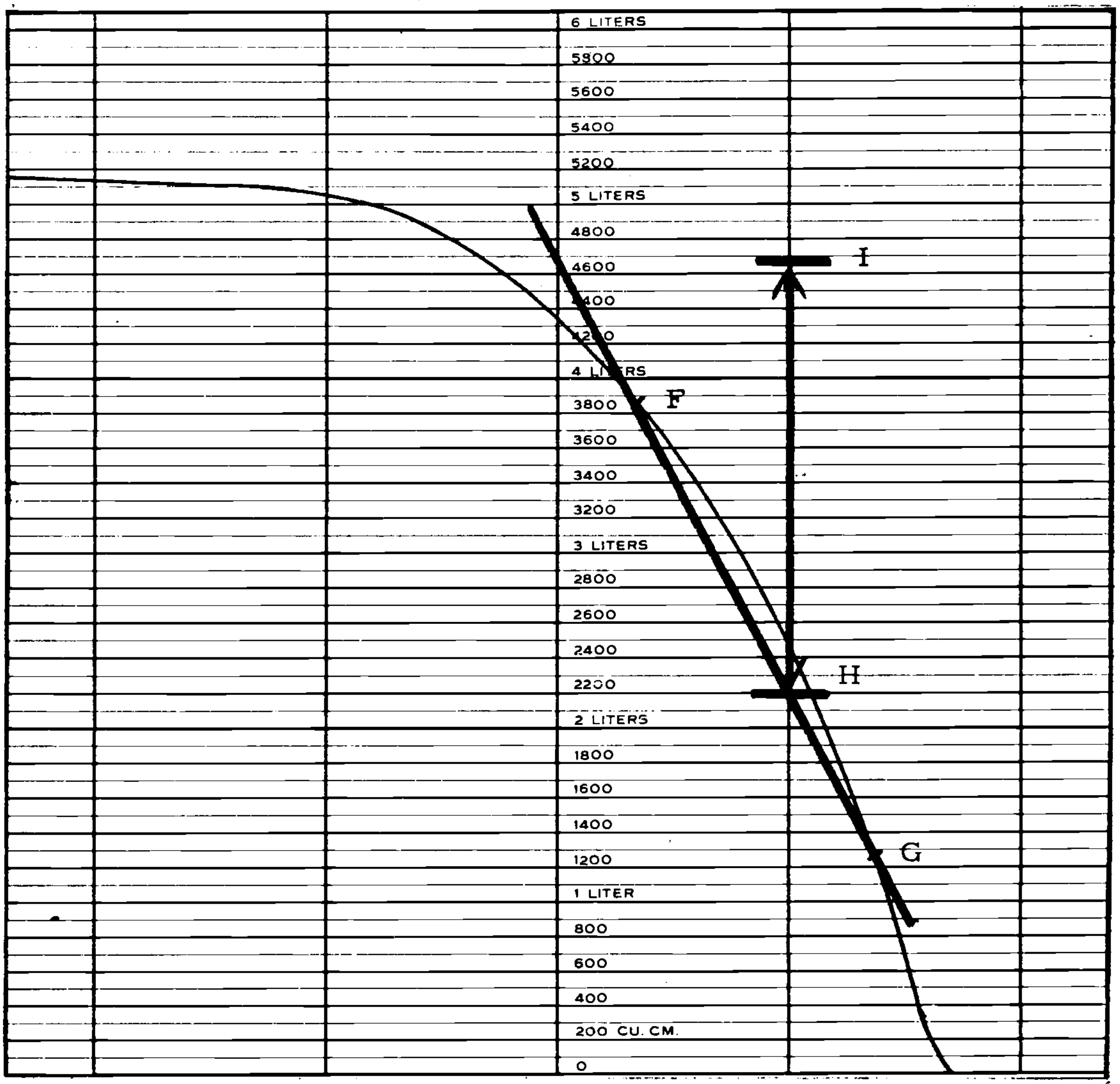

Figure 3. Forced expiratory flow 25 to 75 percent.

chart paper. The lowest intersection was subtracted from the highest to obtain the $FEF_{25-75\%}$ (Point H subtracted from Point I, Figure 3, p. 31).

Forced Expiratory Flow 75 to 85 Percent ($FEF_{75-85\%}$)

This was the average rate per second of flow between the 75 to 85 percent segment of the forced vital capacity. The $FEF_{75-85\%}$ was calculated in Figure 4 (p. 33). Ten percent of the FVC was added to the mark (Point F) at 75 percent on the spirogram curve to arrive at Point K. A line was drawn connecting these points and intersecting two one-second lines. The lowest intersecting point was subtracted from the highest point to obtain the $FEF_{75-85\%}$ (Point O subtracted from Point P in Figure 4, p. 33).

Testing Equipment

The spirometers used in this study were nine-liter Stead-Wells with a plastic bell. The instrument used to collect data at the Emphysema Screening and Research Center of the Oregon Lung Association in Portland, Oregon was also used in the study in the Willamette Valley with the nonsmoking population (Figure 5, p. 34). A similar model nine-liter spirometer with plastic bell was used at the Veterans Administration Hospital in Portland, Oregon.

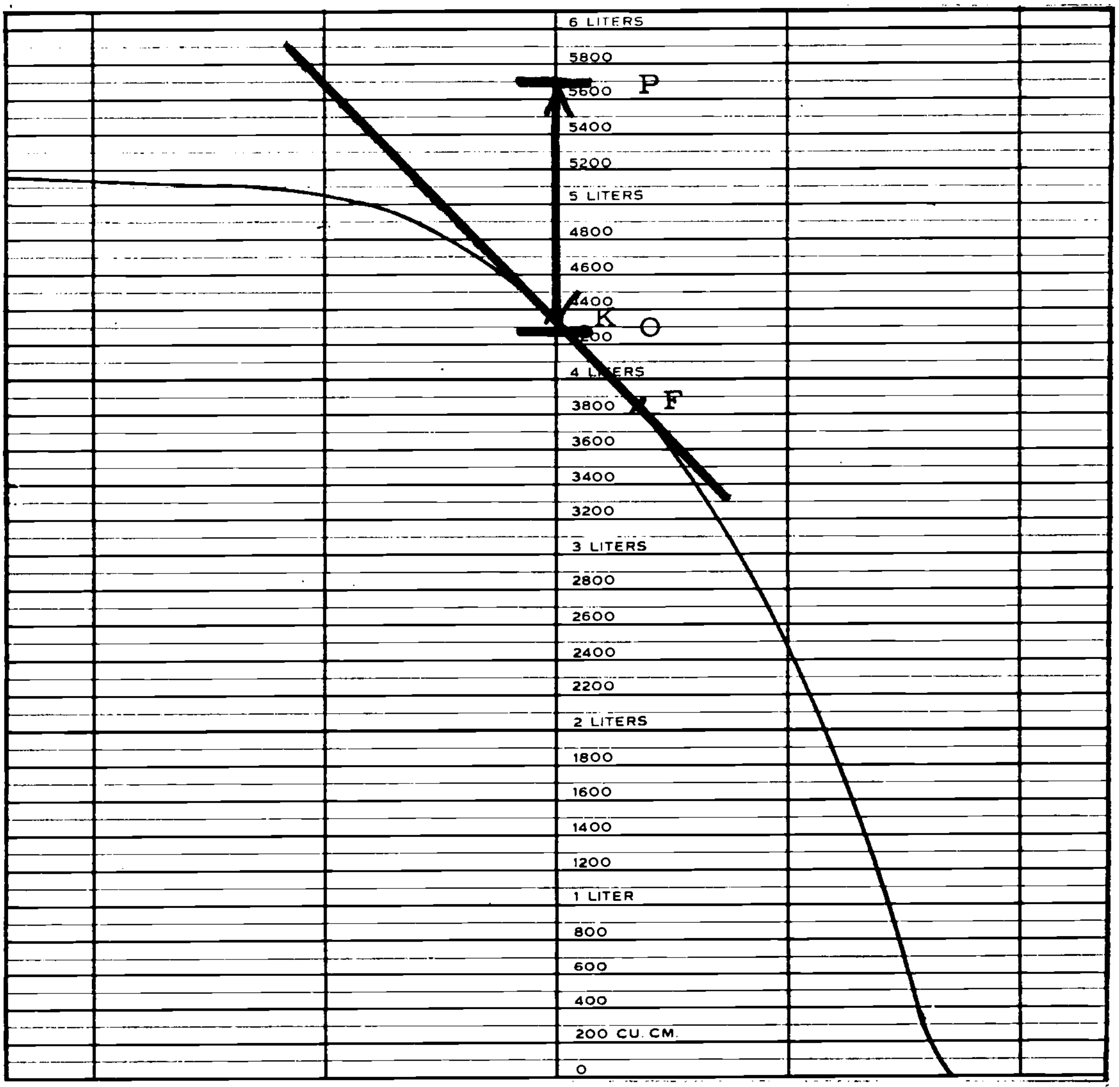

Figure 4. Forced expiratory flow 75 to 85 percent.

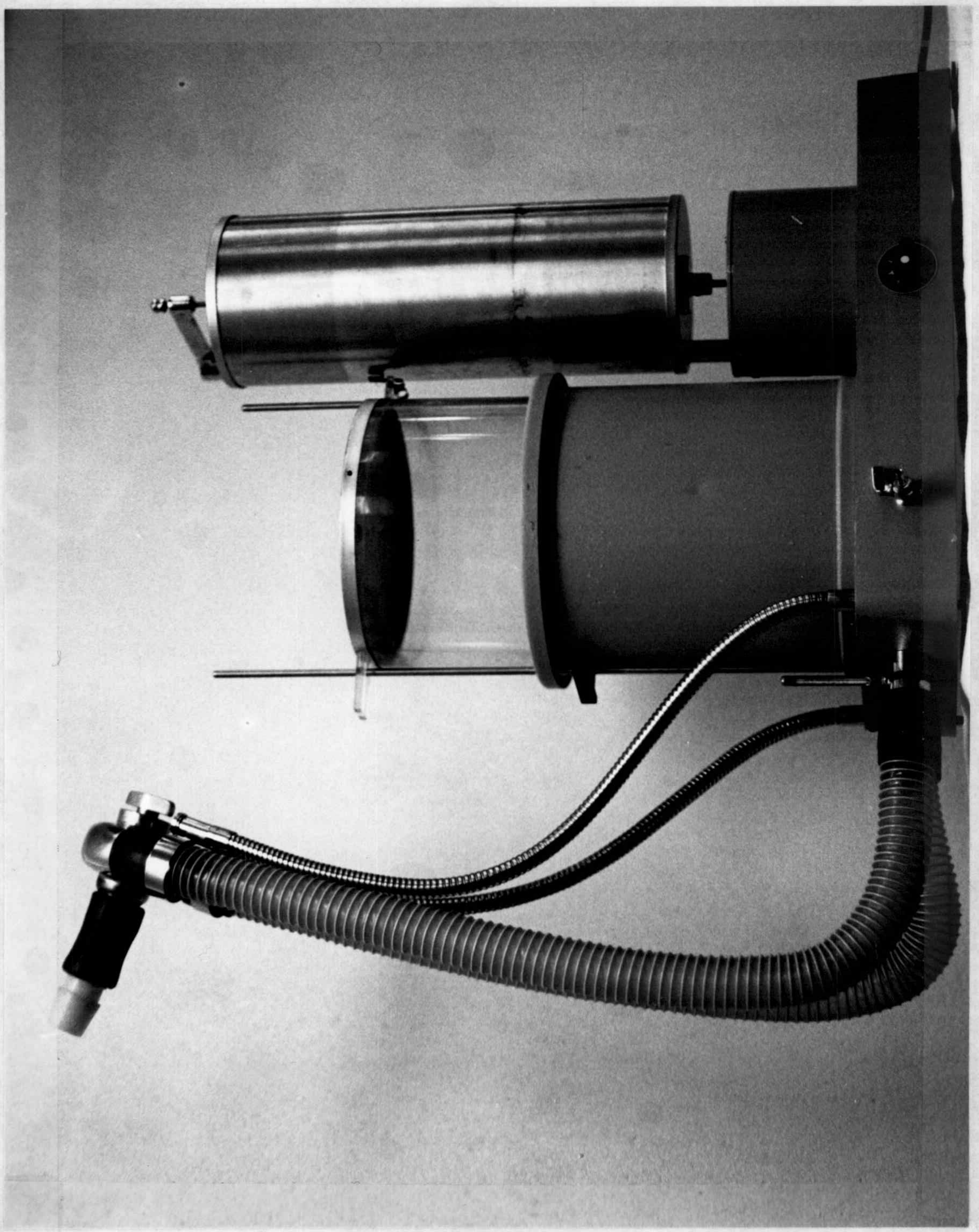

Figure 5. Stead-Wells nine-liter spirometer.

Statistical Procedures

The primary statistical procedure used in this study was to test for significant differences between mean scores of several pulmonary functions for nonsmoking and cigarette-smoking sample populations. Within the smoking population, significant differences between mean scores of pulmonary function near maximal expiratory levels were tested for various classifications of smoking history.

The differences in means were tested for significance at the 0.05 level and 0.01 level by application of the multiple-classification analysis of covariance. The independent variables were individual age, height and smoking habit. The dependent variables were the several pulmonary functions. Regression equations for predictive purposes were computed from mean scores of the pulmonary functions.

Statistical Assumptions

It was assumed that participants were randomly selected from the Willamette Valley and that age, height and smoking habit were relatively homogeneously distributed. Morris and associates (23) collected a large nonsmoking sample (988 subjects) which had similar values of other studies in other parts of the country. The smoking group was comparable to the over 5,000 subjects examined by the Oregon Lung Association.

Other basic assumptions were that the relationship between variables was linear and homoscedastic. Morris and associates, as well as many other researchers, have shown that age and height best relate to lung dimensions (23). Barr concludes that heavy cigarette smoking lowers lung function (1). There has been general agreement that the relationship was homoscedastic.

CHAPTER IV

ANALYSIS AND DISCUSSION OF THE DATA

The purpose of this study was to detect if there was a difference between nonsmoking and smoking sample populations for several segments of the forced vital capacity (FVC) tests. A second purpose in this study was to evaluate several factors relating smoking history to $FEF_{75-85\%}$. These factors included the response to a health screening questionnaire, the age at which the individual commenced smoking, the number of years the person smoked and the number of cigarettes consumed per day. The data for the nonsmoking population was obtained from 240 men between the ages of 30 and 49 years for the values of forced vital capacity (FVC) and forced expiratory flow 25 to 75% ($FEF_{25-75\%}$). Of these 240 men, 213 were evaluated for forced expiratory flow 75 to 85% ($FEF_{75-85\%}$).

These same pulmonary lung functions were measured for 75 men who had a history of consuming ten or more cigarettes per day for at least ten years. This was a combined sample of males between the ages of 30 to 49 years gathered from the Emphysema Screening and Research Center and from the Portland Veterans Administration Hospital.

Nine-liter Stead-Wells spirometers, each equipped with a plastic bell, were used to test all participants. The pulmonary lung functions were recorded and calculated. The raw data were then analyzed by the electronic computer at the Oregon State University Computer Center. The difference in means for the respective pulmonary classifications of nonsmokers and smokers plus smoking history was calculated for significant differences.

Age, Height and Pulmonary Mean Differences of Nonsmokers and Smokers

The age and height characteristics were compared in conjunction with the divisions of the forced vital capacity for nonsmokers and smokers. Analysis of variance tested the effects of the means. Regression equations for predictive purposes were also included in this section.

Age and Height Distribution of Nonsmokers and Smokers

The average age of the nonsmoking group was 3.54 years younger than the smoking population for all lung functions except the $FEF_{75-85\%}$. For $FEF_{75-85\%}$ the nonsmokers averaged 3.6 years younger than the smokers. There was no difference in the average height between the nonsmoking and smoking population except that when comparing the $FEF_{75-85\%}$, the nonsmoking population was 0.77 inches taller than the smoking group.

In all pulmonary function tests the nonsmokers averaged higher scores than the smoking group. The means and standard deviations for smoking and nonsmoking populations for physical and pulmonary dimensions are shown in Table I.

Analysis of Covariance for Pulmonary Lung Functions

An analysis of covariance was used to test $FEF_{75-85\%}$, $FEF_{25-75\%}$ and FVC. The data from these spirometric curve segments were processed through the computer to measure the overall variability and, independently, each of the following variables: age, height and nonsmoking or smoking involvement. By using the linear multiple classification analysis of covariance it was possible to compare unequal sample size groups and concurrently isolate which identified component may affect the variance between the nonsmoking and smoking populations. Tables II through IV represent these analyses of variance for each spirometric segment.

Analysis of Variance: Forced Expiratory Flow Seventy-five to Eighty-five Percent

The analysis of variance, testing the lung function $FEF_{75-85\%}$, for the effect of age, height and smoking, is shown in Table II. All the tests were significant at the 0.01 and 0.05 level. Age was more highly significant than height but smoking history was the most meaningful

Table I. Mean and standard deviation for smoking and nonsmoking populations for physical and pulmonary dimensions.

	Smokers		Nonsmokers			
	$\bar{x}$[a]	SD	$\bar{x}$[b]	SD	$\bar{x}$[c]	SD
Age (years)	41.80		38.26		38.20	
Height (inches)	69.17		69.17		69.94	
$FEF_{75-85\%}$	0.8606	0.3980			1.2262	0.4950
$FEF_{25-75\%}$	3.7748	0.6257	3.9553	0.5790		
FVC	5.004	0.8144	5.2620	0.7820		

[a]N = 75

[b]N = 240

[c]N = 213

Table II. $FEF_{75-85\%}$ analysis of variance testing effect of smoking, age and height.

Testing effect	Source of variation	Sum of squares	df	Variance estimate	F-ratio	Significant
Regression equation[a]	Regression	10.6730	3	3.5576	16.7223	Yes*
	Residual	60.4225	284	0.2127		
	Total	71.0956	287			
Smoking	Regression	4.2610	1	4.2610	20.0271	Yes*
	Residual	60.4242	284	0.2127		
	Total	61.6852	285			
Age	Regression	2.2365	1	2.2365	10.5121	Yes*
	Residual	60.4242	284	0.2127		
	Total	62.6608	285			
Height	Regression	0.8935	1	0.8955	4.1995	Yes**
	Residual	60.4242	284	0.2127		
	Total	61.3177	285			

[a] $FEF_{75-85\%} = 0.2684 \pm 0.1452^{b} - 0.0164(\text{age}) + 0.0205(\text{ht})$ R = 0.3874 SEE = 0.1304

*Significant at the 0.01 level

**Significant at the 0.05 level

[b] Nonsmokers + 0.1452

Smokers - 0.1452

Table III. $FEF_{25-75\%}$ analysis of variance testing effect of smoking, age and height.

Testing effect	Source of variation	Sum of squares	df	Variance estimate	F-ratio	Significant
Regression equation[a]	Regression	29.4563	3	9.8187	37.4576	Yes*
	Residual	81.5225	311	0.2621		
	Total	110.9789	314			
Smoking	Regression	0.9242	1	0.0242	0.0923	No
	Residual	81.5225	311	0.2621		
	Total	81.5467	312			
Age	Regression	10.4817	1	10.4817	39.9866	Yes*
	Residual	81.5225	311	0.2671		
	Total	92.0043	312			
Height	Regression	16.3454	1	16.3454	62.3560	Yes*
	Residual	81.5225	311	0.2621		
	Total	97.8680	312			

[a] $FEF_{25-75\%} = -0.9465 - 0.03371\,(age) + 0.0884\,(ht)$ $R = 0.5151$ $SEE = 0.2254$

*Significant at 0.01 level

Table IV. FVC analysis of variance testing effect of smoking, age and height.

Testing effect	Source of variation	Sum of squares	df	Variance estimate	F-ratio	Significant
Regression equation[a]	Regression	61.3468	3	20.4489	46.1795	Yes*
	Residual	137.7151	311	0.4428		
	Total	199.0620	314			
Smoking	Regression	0.0002	1	0.0002	0.0006	No
	Residual	137.7151	311	0.4428		
	Total	137.7154	312			
Age	Regression	10.1057	1	10.1057	22.8228	Yes*
	Residual	137.7151	311	0.4428		
	Total	147.8214	312			
Height	Regression	46.1707	1	46.1707	104.2667	Yes*
	Residual	137.7151	311	0.4428		
	Total	183.8859	312			

[a] FVC = -3.926 - 0.335 (age) + 0.1494 (ht)   R = 0.5551   SEE = 0.3698

*Significant at 0.01 level

examination. The appropriate predictive regression equation was calculated by the computer using age, height and smoking history.

Analysis of Variance: Forced Expiratory Flow Twenty-five to Seventy-five Percent

The results from the analysis of variance testing the spirometric curve $FEF_{25-75\%}$ are shown in Table III. The total regression was significant and the variable age and height were also highly significant tests. There was no significant difference between the nonsmoking and smoking populations for this segment of the curve. Therefore, the regression equation for the prediction of $FEF_{25-75\%}$ included only factors for age and height.

Analysis of Variance: Forced Vital Capacity

Table IV presents the analysis of variance testing the spirometric curve FVC. As was found for the average rate of flow per second of the middle half of the spirogram curve (Table III), all tests except the smoking effect were significant. This was reflected in the regression equation for predicting the FVC.

Health and Smoking History Factors Related to Forced Expiratory Flow Seventy-five to Eighty-five Percent

Several factors which may be related to smoking and to lung function disability were compared in the following section. These factors included results from a screening questionnaire, the age the individual started smoking, the number of years the person smoked and the number of cigarettes consumed per day. Comparisons to the $FEF_{75-85\%}$ were made by a linear analysis of variance. The 75 males from the smoking group were used for the sample.

Response to Health Screening Questionnaire

Table V displays the mean and standard deviation for the response to the health questionnaire (Appendix A). Individuals who answered "no" to the first 11 questions were classified normal negative. A "yes" answer for any of the first 11 questions would be classified as abnormal positive. The analysis of variance in Table VI notes that there was a significant difference between lung function and the screening questionnaire.

Table V. Mean and standard deviation of $FEF_{75-85\%}$ for response to pulmonary health questionnaire. (n = 75 smokers)

Category	Percent included	$\bar{x}$	SD
Normal negative	34	1.0469	0.4521
Abnormal positive	65	0.7618	0.3302

Table VI. Linear analysis of variance[a] response to pulmonary health questionnaire for $FEF_{75-85\%}$.

Source of variation	Sum of squares	df	Variance estimate	F-ratio	Significant (0.01 level)	R
Between groups	1.3805	1	1.3805	9.7420	Yes	0.3431
Within groups	10.3450	73	0.1417			
Total	11.7255	74				

[a] $Y = \mu + \alpha_i$

Age at Which Individual Began Smoking Habit

There were three arbitrary divisions of smokers grouped according to age at which the individual started smoking regularly. The majority of the smoking population belonged to the category of smokers who started the habit before age 20. The middle group, age 20 to 24, had 18 percent of the smokers while the last group, which included those who began smoking after reaching age 25,had only four percent of the population. There was no significant difference between any of these groups. Table VII presents the mean and standard deviation for the three divisions of smokers. Table VIII shows the analysis of variance with the negative significance.

Years of Continuous Smoking

Table IX presents the data on the number of years the individuals smoked. The parameters of this study were based on a minimum of a ten-year smoking habit. The majority of people had smoked for at least 20 years and 12 percent had smoked for at least 30 years. Table X shows that smokers who have continued to smoke for the longer time periods have a significantly lower $FEF_{75-85\%}$.

Number of Cigarettes Smoked per Day

Table XI presents the four categories of smokers grouped by

Table VII. Mean and standard deviation of $FEF_{75-85\%}$ for age when individual smokers started habit. (N = 75)

Age started smoking (yr)	Percent included	$FEF_{75-85\%}$	
		$\bar{x}$	SD
< 20	77	0.8886	0.4053
20-24	18	0.7614	0.3365
< 25	4	0.7833	0.5868

Table VIII. Linear analysis of variance[a] for age individual started smoking for $FEF_{75-85\%}$.

Source of variation	Sum of squares	df	Variance estimate	F-ratio	Significant (0.01 level)	R
Between groups	0.2011	2	0.1005	0.6283	No	0.1309
Within groups	11.5245	72	0.1600			
Total	11.7256	74				

[a] $Y = \mu + \alpha_i$

Table IX. Mean and standard deviation of $FEF_{75-85\%}$ for years of continuous smoking. (N = 75)

Years of smoking	Percent included	$FEF_{75-85\%}$ $\bar{x}$	$FEF_{75-85\%}$ SD
10-19	22	1.0135	0.3503
20-29	65	0.8724	0.4113
> 30	12	0.5077	0.1198

Table X. Linear analysis of variance[a] for years of continuous smoking for $FEF_{75-85\%}$.

Source of variation	Sum of squares	df	Variance estimate	F-ratio	Significant (0.01 level)	R
Between groups	1.5248	2	0.7624	5.3812	Yes	0.3606
Within groups	10.2008	72	0.1416			
Total	11.7256	74				

[a] $Y = \mu + \alpha_i$

number of cigarettes smoked per day. Few individuals (two percent) smoked only ten cigarettes every day. The majority of smokers were in the second group which consumed 11 to 30 cigarettes per day. Table XII shows that there was no significant difference between groups comparing the number of cigarettes smoked per day.

Table XI. Mean and standard deviation of $FEF_{75-85\%}$ for the number of cigarettes smoked per day. (n = 75)

Cigarettes smoked per day	Percent included	$FEF_{75-85\%}$ $\bar{x}$	$FEF_{75-85\%}$ SD
10	2	1.4450	0.0777
11-30	66	0.8754	0.3679
30-50	26	0.7900	0.4583
> 51	4	0.6966	0.3317

Table XII. Linear analysis of variance[a] of $FEF_{75-85\%}$ for the number of cigarettes smoked per day.

Source of variation	Sum of squares	df	Variance estimate	F-ratio	Significant (0.01 level)	R
Between groups	0.8743	3	0.2914	1.9068	No	0.2730
Within groups	10.8513	71	0.1528			
Total	11.7256	74				

[a] $Y = \mu + \alpha_i$

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The pulmonary lung functions of sample populations of nonsmokers and smokers were compared. The nonsmoking population was composed of 240 men who were tested for the values of forced vital capacity and forced expiratory flow 25 to 75 percent. Twenty-seven kymograph tracings were lost from this original study, therefore, only 213 males were evaluated for forced expiratory flow 75 to 85 percent. The smoking sample population contained 75 men who had a history of consuming ten or more cigarettes per day for at least ten years. All participants were between the ages of 30 and 49.

A Stead-Wells spirometer was used to obtain the following pulmonary function tests: forced vital capacity (FVC), forced expiratory flow in one second (FEV_1), forced expiratory flow 25 to 75 percent ($FEF_{25-75\%}$) and forced expiratory flow 75 to 85 percent ($FEF_{75-85\%}$). Differences between the nonsmoking and smoking population were determined by using linear analysis of covariance. Predictive regression equations were formulated for nonsmokers and smokers for FVC, $FEF_{25-75\%}$, and $FEF_{75-85\%}$.

Summary

There was a significant difference between the nonsmoking and smoking population for the lung function $FEF_{75-85\%}$. The null hypothesis of this research was that there would be no difference in the $FEF_{75-85\%}$ segment of the spirometric curve scores of the smoking and nonsmoking populations. Thus, the null hypothesis was rejected. There was no significant difference between the sample nonsmoking and smoking population for the FVC or the $FEF_{25-75\%}$ segment of the spirometric curve. The covariates, age and height, were significantly different for all lung functions tested.

The evaluation of several factors relating smoking history to $FEF_{75-85\%}$ was also noted. Those individuals who responded positively (symptoms of pulmonary disease) to the health screening questionnaire had a significantly lower pulmonary lung function. The groups of smokers who smoked for longer time periods also had lower $FEF_{75-85\%}$. The results were inconclusive for ascertaining if the age at which smokers began the habit or if the number of cigarettes per day affected $FEF_{75-85\%}$.

Conclusions

On examination of the comparative results among the various lung functions tested it seems apparent that smoking reduces the $FEF_{75-85\%}$ in healthy men ages 30 to 49, inclusively. This was not shown for the FVC or the $FEF_{25-75\%}$. In general, the more years an individual smokes (minimum of ten cigarettes per day), the lower his test score $FEF_{75-85\%}$. Testing the forced expiratory capacity flow rates farthest from total lung capacity may be a more critical test than the FVC or $FEF_{25-75\%}$ because it not only demonstrates significant differences between smokers and nonsmokers but also shows differences between groups of smokers depending on how long they have smoked. If an individual smoker has any symptoms of pulmonary damage as defined through the Emphysema Screening and Research Center questionnaire, his spirometric segment $FEF_{75-85\%}$ will average significantly lower than other smokers who are the same age and height. Unpublished data on over 2500 smokers by the Oregon Lung Association were unable to confirm significant results comparing the questionnaire to $FEF_{25-75\%}$ (25). The forced vital capacity test 75 to 85 percent appears to be a better test than the forced vital capacity test 25 to 75 percent for distinguishing early symptoms of chronic obstructive lung disease.

Recommendations

Additional research should be completed with a large sample of smokers. The present sample tended to have individuals who started smoking at nearly the same age in life and who smoked about the same number of cigarettes per day. More emphasis on the exact age an individual started smoking would be helpful. A test-retest of a smoking population could also be undertaken. Research of female populations would increase the base of knowledge for early detection of lung diseases. The regression equations in this study should be integrated into nomograms for utilization by physicians interested in testing lung function of young male cigarette smokers.

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APPENDICES

APPENDIX A

HEALTH QUESTIONNAIRE

(Adapted from the Oregon Lung Association Emphysema Screening Center)

Please check (Yes or No) or answer questions:

		Yes	No
1.	Do you usually cough for as many as three months each year?	___	___
2.	Do you usually bring up any mucus, sputum or phlegm from your chest for as many as three months each year?	___	___
3.	Do you usually cough or have to clear your throat in the morning or when getting up? (50 or more days a year)	___	___
4.	Do you usually cough up any mucus, sputum or phlegm from your chest during the day? (50 or more days a year)	___	___
5.	Do you have to stop for breath when walking at your own pace on level ground?	___	___
6.	Do you have to stop for breath when walking with other people of your own age on level ground?	___	___
7.	Do you wheeze a total of 50 days or more each year? (breath with a whistling sound)	___	___
8.	Do you have a post nasal drip? (drainage from the back of your nose)	___	___
9.	Have you ever been told by a doctor you have had any of the following: Asian flu, asthma, chronic bronchitis, emphysema, hay fever, heart trouble, or tuberculosis?	___	___

10. Have you had pneumonia, pneumonoconiosis, or sarcoidosis? ___ ___

11. Have you ever had an operation affecting your chest or a chest injury? ___ ___

12. Have you ever worked at a job where you breathe smoke, dust or fumes? ___ ___

13. Have you ever lived or worked in an area where air pollution is a problem? ___ ___

14. At what age did you start smoking regularly? _________ years old.

15. Do you inhale when smoking? ___ ___

16. Do you usually smoke a filter cigarette? ___ ___

17. Approximately how long have you smoked? _________ years.

18. What is the average number of cigarettes you smoke per day? _________

19. If you no longer smoke cigarettes did you stop less than 6 months ago? ___ ___

20. Have you ever had a tuberculin skin test that got very red? ___ ___

APPENDIX B

SAMPLE LETTER TO EMPLOYEES OF VETERANS ADMINISTRATION HOSPITAL

To: Edward L. Conkievich
Nursing Service (118)

From: Dr. James Morris,
Chief, Pulmonary and Infectious Diseases

Subject: Volunteer for Standard Breathing Test

Dear Edward:

Some time during the middle of this month you will have a chance to contribute ten minutes of your time toward a better understanding of human health. You have been personally selected to participate in a special health study which includes a questionnaire and a standard breathing test. This study is a free medical diagnostic test. Your results will be analyzed in relation to hundreds of men your age and height.

This project is being sponsored by Oregon State University, and has the support of the Veterans Administration Hospital and the Oregon Lung Association.

1. The testing will take place on December 18th and 19th.

2. You were selected because you are between the ages of thirty and forty-nine. We need you for this study if you have smoked at least a half-a-pack of cigarettes a day for ten years. You are still eligible to be examined even if you have quit six months ago.

3. You need only your supervisor's permission to cooperate in this research. All you have to do is fill out the enclosed card and return it through the hospital distribution mail system.

4. The test will be conducted in building 25, room 531 of the VA Hospital. We will contact you before you come to take the test so there will be minimal waiting time and work loss for you.

5. This test is a standard exam of the forced vital capacity and is essentially the same one given to patients and health people at this hospital. Twenty questions concerning your health and smoking history are asked. These questions were developed by researchers at this VA Hospital, the Oregon Lung Association and Oregon State University and have been used for several years as preliminary indicators of healthy lungs.

6. Please fill out the enclosed questionnaire and bring it with you when you come for testing.

7. All tests will be under the jurisdiction of Dr. Morris, Chief of Pulmonary and Infectious Diseases. Your test results and questionnaire will be confidential. This research is not concerned with personal smoking attitudes and there will be no pressure either intended or implied that you should stop smoking.

8. Any questions or inquiries concerning this survey will be freely answered by Dr. Morris, telephone extension 564. You may withdraw at any time and there are no bindings on you to participate.

9. You are completely covered under the Department of Health, Education and Welfare regulations which protect you as a human subject. By signing the attached card and indicating your willingness to join the program you do not waive any of your legal rights, or release this institution or its agents from liability for negligence.

Sincerely,

Dr. James Morris
Chief, Pulmonary and Infectious
 Diseases Section
Veterans Administration Hospital

APPENDIX C

LETTER SENT TO HOSPITAL SECTION CHIEFS

To: All Chiefs of Service
VAH, Portland, Oregon

From: James F. Morris, M. D.
Section Chief, Pulm. & Infect. Dis.

Subject: Volunteer for Standard Breathing Test

Employees whose names appear on the attached list are being contacted today to ask their cooperation in conducting breathing tests in this hospital. This project has been cleared by the Station Administrative Office, and is sponsored by our VA Hospital, the Oregon Lung Association and Oregon State University. Each employee listed will receive a letter, a questionnaire form, and a card to fill out and sign, to be initialed by the supervisors involved, and returned to Dr. Morris, 25 E, just as soon as possible, in order to set up schedules for tests on next Tuesday, December 18 and Wednesday, December 19. We ask that you gather these cards as you initial them, and see that they reach Dr. Morris by this Friday, December 14, if at all possible.

If there are any questions on your part, or on the part of employees in your section, please feel free to call me on Ext. 564.

Thank you very much for your help in this research program at our hospital.

James F. Morris, M. D.