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The Effects of Progressive Relaxation and Myoelectric Feedback on Respiratory Resistance in Bronchial Asthmatics

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THE EFFECTS OF PROGRESSIVE RELAXATION AND MYOELECTRIC FEEDBACK ON RESPIRATORY RESISTANCE IN BRONCHIAL ASTHMATICS

by

Daphne Browne Shah

An Abstract of a Thesis

in Partial Fulfillment of the Requirements

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ABSTRACT

For the individual with bronchial asthma, an asthmatic attack can be a life threatening experience. A theory of bronchial asthma as a conditioned response has been recently proposed by several investigators. It was suggested that this conditioned response may be modified by lowering the arousal level, and as a result, decreasing the asthmatic response.

The problem identified in this exploratory study was to measure the effects of relaxation on the smaller or peripheral airways of a convenience sample of six asthmatic subjects fourteen to seventy years of age. It was hypothesized that an increased degree of total body relaxation would result in a decrease in airway resistance as would be evidenced by the changes in certain pulmonary function tests performed.

The six asthmatic subjects participated in the study after referrals by their physicians. At a pre study session the subjects were introduced to the objectives of the study. Identifying information was recorded, and after the base line physiological measurements were taken, details of the relaxation training program were explained to each subject.

The base line measurements consisted of the subjects' tension levels recorded with an electromyograph, with the surface electrodes on the skin over the frontalis muscle. The base line also consisted of the following pulmonary function tests: closing capacity and closing volume, forced expiratory volume, forced vital capacity, maximal mid-expiratory flow rate, residual volume and total lung capacity.

The subjects were introduced to the intervention of purposeful relaxation training using an electromyograph biofeedback unit. They were to practice the relaxation exercises at home at least twice each day of the four week study. Each of the six subjects attended eight relaxation training sessions using the biofeedback techniques. The investigator was present at all of the laboratory sessions, and recorded integrated electromyographic values during two-minute periods. Each of the eight relaxation training sessions lasted twenty-four minutes, and the means of the electromyographic values were reported in microvolts.

The tension levels measured during the sessions for each subject fluctuated within the sessions, generally showing a decrease within the sessions. This decrease was not continuously progressive over the eight sessions.

The short term evaluation of the relaxation intervention was determined by performing the pulmonary function tests before and after each of the last two sessions. The long term evaluation was made by repeating the tests at the end of the study. The results of the pulmonary function tests did not indicate that an increase in total body relaxation resulted in a decrease in airway resistance of the six asthmatic subjects studied.

Subjective findings reported at the end of the study did indicate that the subjects were able to relax and to decrease the frequency and intensity of their asthmatic symptoms. It was concluded that the hypothesis was not supported by the findings of the study, even though the subjective findings indicated that this might be possible. It was further concluded that there were some uncontrolled factors present in the study

which might have affected the pulmonary function tests. These factors included cold air, exposure to certain pollens and smog, some emotional factors, and the stressful effects of taking several pulmonary function tests which required forced breathing.

It was recommended that further studies dealing with this subject should consider certain changes in the areas of sampling and methodology. These changes should allow for a larger sample which would be more representative of the population. The changes in methodology would include the use of a control group, having the subjects in closer proximity to the laboratory, and allowing the investigator to supervise the subjects' practice of the relaxation exercises.

It was also recommended that further nursing studies be done to explore the feasibility of teaching asthmatic patients systematic relaxation techniques during incidental nursing encounters.

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Each person whose signature appears below certifies that this thesis in his opinion is adequate, in scope and quality, as a thesis for the degree Master of Science.

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--Daphne Browne Shah

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LIST OF ABBREVIATIONS

CC	Closing Capacity
CV	Closing Volume
EMG	Electromyograph
FEV	Forced Expiratory Volume
FRC	Functional Residual Capacity
FVC	Forced Vital Capacity
MMF	Maximal Mid-expiratory Flow Rate
RV	Residual Volume
TLC	Total Lung Capacity
CC/TLC	Closing Capacity/Total Lung Capacity
CV/VC	Closing Volume/Vital Capacity
RV/TLC	Residual Volume/Total Lung Capacity

Chapter I

INTRODUCTION

Observations of physicians, nurses and paramedical personnel dealing with asthmatics during acute attacks indicate that the patient is often asked to rest or sit quietly and relax at the onset of the attack, or even during the asthmatic episode. Patients often report that their distress becomes less when they are able to relax during an asthmatic attack.

Experience with asthmatic children at one research center suggested that many asthmatics experienced more bronchoconstriction when they were not able to relax, while those children who were able to relax showed some objective as well as subjective improvement in their asthmatic symptoms (Alexander et al., 1972). In studies involving adult asthmatics, Moore (1965) noted that relaxation served the role of increasing the individual's tolerance towards his symptoms, and in a preliminary report, Green and Pranke (1974) noted both objective and subjective improvements in the subjects they studied who were able to relax. These observations suggested that there may be a relationship between tension and asthma, and that training in purposeful relaxation might be of some benefit to asthmatics in preventing or reducing the severity of their asthmatic attacks.

Purpose of the Study

The purpose of this study was to determine the effects of relaxation training on the small peripheral airways of subjects with either

intrinsic or extrinsic asthma, and to note any implications for nursing care of the asthmatic patient which evolve from this study. This descriptive study was designed to measure the effects of relaxation training on the respiratory system of six asthmatic subjects by measuring airway resistance before and after the relaxation intervention, and by assessing the subjective responses reported.

Assumptions

The following assumptions were made for the purpose of the study:

(a) Asthma is a condition which is affected by both physiological and psychological factors.

(b) Asthma is a learned response to certain stressful situations occurring in the environment.

(c) The lessening of muscle tension is positively correlated with the presence of relaxation in that muscle or muscle group.

(d) The tension of the frontalis muscle is positively correlated with the level of total body tension.

Hypotheses

The general hypothesis of the study was that an increased degree of total body relaxation would result in a decrease in airway resistance.

In order to suggest some objective and quantitative approaches which would indicate airway resistance changes in the study, the following sub-hypotheses were proposed:

(1) The difference between the means of the closing capacity (CC) and closing volume (CV) as measured by the Ohio Nitrogen Analyser before and after the relaxation training would show a decrease.

(2) The difference between the means of the forced expiratory volumes in one (FEV_1) and three seconds (FEV_3) taken before and after the relaxation training would show an increase.

(3) The difference between the means of the functional residual capacity (FRC) taken before and after the relaxation training would show a decrease.

(4) The difference between the means of the forced vital capacity (FVC) taken before and after the relaxation training would show an increase.

(5) The difference between the means of the maximal mid-exploratory flow rates (MMF) taken before and after the relaxation training would show an increase.

(6) The difference between the means of the residual volume (RV) taken before and after the relaxation training would show a decrease.

Definition of Terms

For the purpose of this study the following terms were defined:

Biofeedback. Biofeedback refers to techniques whereby the bioelectric component of a physiological response or a transduced electrical signal is connected to a visual, auditory or tactile display which is viewed, heard, or felt by the user.

Muscle tension. Muscle tension, or tension, refers to the shortening of muscle fibers. This shortening or tensing of the muscle fibers is reversible by relaxing the same muscle or muscle groups.

Relaxation. Relaxation denotes a lessening of muscle tension or muscle tightness. It is suggested that relaxation and tension are highly

incompatible, and therefore cannot exist together in the same muscle or muscle group at the same time.

Airway resistance. Airway resistance refers to the pressure differential required for a unit of airflow change (centimeter of water per liter per second), and is always measured under dynamic conditions.

Closing volume. Closing volume refers to that lung volume at which the dependent lung zones cease to ventilate. Presumably it is that portion of the lung volume between the start of the closing of the airways and the residual volume.

Forced expiratory volume. Forced expiratory volume is that volume of air which is expired forcefully, with maximum effort, in a specified time. In this study the forced expiratory volumes were measured in one and three seconds.

Functional residual capacity. Functional residual capacity is the amount of air that remains in the lungs after each normal expiration.

Forced vital capacity. Forced vital capacity is the total expired volume of air during a forced expiration following a maximal inspiration.

Maximal mid-expiratory flow rate. Maximal mid-expiratory flow rate is the measurement of the flow of air from the lungs, measured in liters per second, in the middle half of the forced vital capacity.

Residual volume. Residual volume is the volume of air remaining in the lungs after a maximum expiration.

Total lung capacity. Total lung capacity is the measurement of all the air that the lungs can contain after a maximum inspiration.

Scope of the Study

The sample was chosen because of its convenience, and consisted of six subjects ranging in age from 14.0 to 70.0 years, who had previously been diagnosed as bronchial asthmatics. The diagnoses were made by the physicians at the Loma Linda University Medical Center on the basis of clinical examinations, pulmonary function tests and radiologic studies. The subjects were under the medical supervision of the Section of Medical Chest Diseases of the Loma Linda University Medical Center. The sample size was limited by the criteria set for the study and by the availability of the population.

The subjects were tested to determine their pulmonary status before the relaxation intervention and again after the intervention to note any significant changes in the pulmonary functions measured. Statements were made from the measurements of pulmonary function changes in relation to the relaxation intervention.

Limitations of the Study

The following variables were not controlled during the study, but were recognized as capable of affecting the outcome of the study:

a. The participants' thoughts which would affect their anxiety level, or their ability to relax.

b. The physiological state of the participants during the study.

c. The ability of the participants to practice the relaxation exercises as instructed, and the amount of time available to them to learn the relaxation technique.

d. The ability of the participants to learn the technique of purposeful relaxation.

e. Any medications that the participants were taking regularly or on an emergency basis during the study, which were related to their asthmatic attacks.

Significance of the Study

Individuals involved with the care of asthmatics recognize that the effects of tension and anxiety add to the general discomfort caused by the bronchoconstriction. Comroe (1969) stated that the chief difficulty with the asthmatic lung lies in the obstruction of the smaller airways. Some of the measurements used in this study were intended to give an indication of the status of these smaller airways, and therefore might be indicative of the effects of relaxation on the airways of asthmatic subjects.

Chapter II

REVIEW OF LITERATURE

Introduction

Breathing can be considered an obligatory act in the maintenance of life, and distress is often experienced when the work of breathing becomes excessive. Bronchial asthma is one disease state in which this distress can be acute. In a study by Masuda (1966), relating emotional and adrenal reactions to stress in bronchial asthmatics, a possible sympathetic nervous system dysfunction was noted in those subjects studied.

The way in which the psychological variables of stress affect the internal and behavioral mechanisms of the asthmatic is not clear, but it has been suggested that asthma may be viewed as a behavior which the organism has learned to use to meet his needs (Turnbull, 1961).

In considering the symptoms presented in an asthmatic attack, dyspnea is the one most frequently noted, and the one presenting the most discomfort. Dyspnea has also been noted as an emotional response of the asthmatic when he is presented with stress or tension (Knapp et al, 1966).

In pulmonary insufficiency, such as occurs in asthma, it is desirable for the asthmatic to learn a more efficient method of controlling his breathing. This presents one area of potential for the application of an operant conditioning technique with physiological feedback such as a technique of purposeful relaxation training with an electromyographic biofeedback unit.

A review was made of some research studies concerned with relaxation training and the use of biofeedback with bronchial asthmatic subjects and the related physiological measurements. Studies were also reviewed which indicated a relationship between tension caused by anxiety and episodic attacks of asthma in asthmatic subjects. The rationale for the selection of the physiological measurements used in the study is presented in chapter three.

BRONCHIAL ASTHMA

Asthma has been defined as a disorder of function, varying in severity over periods of time. Asthma has also been defined as a disease characterized by variable degrees of dyspnea due to widespread narrowing of bronchial airways. This condition changes in severity over short periods of time either spontaneously or under treatment, but not due to cardiovascular disease (Scadding, 1971; Fletcher, 1971).

Among those patients who have been diagnosed as asthmatics with the related functional disorders, are found two classes of asthma, classified according to the origin of the dysfunction. One group, labeled extrinsic asthma, can be attributed to reagin hypersensitivity. The other group, intrinsic asthma, exhibits only the clinical symptoms with the absence of any recognizable antigen-antibody reactions (Scadding, 1971).

The intrinsic type of asthma usually occurs late in life, and also frequently occurs in subjects with lung infection or chronic lung diseases. The clinical picture strongly resembles that of extrinsic asthma without the specific sensitivity to allergens (Donald, 1971).

Throughout this review of the literature, no single causative factor has been found to determine the etiology of asthma. It has been suggested that a variety of factors may be involved in the development and continuance of the dysfunction. The psychological variables involved with asthma have been varied and significant, and it has been frequently suggested that the focus in the care of the asthmatic should be placed on these variables (Weiss, 1973; Reis, 1964; Dekker, 1961; Edgell, 1952).

The pathophysiological findings during an episode of asthma show one or more of the following alterations of the respiratory function: (a) forced expiratory flow rate, maximum voluntary ventilation and vital capacity are all decreased, (b) airway resistance and residual lung volume are increased, (c) there are mismatched ventilation/perfusion patterns, and there is (d) the resulting hypoxemia (Comroe, 1969; Rodman et al, 1969).

Learning a Factor in Bronchial Asthma

It has been pointed out in the literature reviewed that individuals with skin sensitivity do not always experience asthmatic symptoms when the allergic substance is presented, while at other times the asthmatic symptoms appeared when the presence of the allergic substance was only suggested (Dekker et al, 1956). These observations suggest that the consideration of psychological variables may help to explain the apparent variance.

Animal studies have shown some success in producing conditioned asthmatic responses in the guinea pig. The only individual differences in the susceptibility of the animals to the asthma attacks that were

shown, were related to the intensity of the attacks (Ottenberg, 1958). Turnbull noted that if asthma can be viewed as a substitute behavior which the individual organism has learned to use successfully in a stress situation, then it should be possible to apply principles of learning to aid in understanding the psychological variables involved (Turnbull, 1961). As early as 1939 Brogden reported an experiment in which he used dogs, employing Pavlovian procedures to study the conditioned response. This experiment suggested that once a response is elicited, it can be maintained indefinitely if it continually leads to sufficient reinforcement. If the asthmatic behavior is used successfully in any situation as Turnbull stated, its successful use can lead to a reinforcement of the asthmatic behavior.

It has also been demonstrated that certain psychological factors are related to asthma, most likely acting as trigger factors. Since all asthma does not respond to the conventional treatment of the disease, other variables should be sought as alternative mechanisms involved with the asthmatic condition. Howell (1971) included among these variables those trigger factors which act centrally on the efferent nervous pathways to the bronchi. In this category of nervous responses, he included the conditioned response.

Recently this concept of a learned or conditioned response has been proposed by many investigators (Dekker et al., 1956; Franks et al., 1959; Rees, 1964; Weiss, 1973). The literature reviewed suggested that a conditioned bronchospasm is the result of both physical and emotional mechanisms. Dekker et al. (1956) concluded that the emotional stimuli become integrated with allergic and other stimuli, and that the conditioning or deconditioning depended on heredity and other acquired factors.

Moore (1965) reported the removal of the conditioned response by the effects of desensitization. Reports of the effects of verbal desensitization on the conditioned response of asthma have been made by other researchers (Sergeant et al., 1969; Yorkston et al., 1969; Silverstone et al., 1967). In verbal desensitization, the investigators presented the stimulus factors in a hierarchy of intensity, with the least intense represented first. They found that the subjects were able to avoid the asthmatic attack when presented with the verbal stimuli after they were desensitized.

Dyspnea - A Symptom of Asthma

Dyspnea means primarily a desire for air, or the mental anguish associated with the effort to be able to ventilate enough to satisfy the air demand (Guyton, 1971, 361). Dyspnea is subjective, and like pain, it involves both perception of the sensation and the reaction to the sensation. Comroe (1969) stated that dyspnea must be differentiated from tachypnea, which is rapid breathing, and from hyperventilation, which is ventilation in excess of metabolic requirements.

Dyspnea is a relatively broad term which encompasses many varying types of ventilatory discomfort. Some of these types of discomfort include the obstructed breathing experienced during an acute asthmatic attack, and the sensation of being unable to get a deep enough breath during an emotionally induced episode of hyperventilation (Rapaport, 1971).

Many factors contribute to dyspnea. There is no uniform agreement among interested investigators about the relative importance of the aspect of each functional disturbance which is involved in its pathogenesis. Other aspects of the problem of dyspnea that need some clarification are

the nature of the stimuli provoking the discomfort, and the sensory receptors and nerve pathways which participate in the individual's awareness of this symptom (MacBryde, 1970, 341).

A general classification of dyspnea has been given in which are listed three broad groups of the symptom. First, there is an awareness of an increased ventilatory effort. If this is the normal relationship to an increase in oxygen consumption, then the increased ventilation may be due either to various organic causes of hyperventilation or it may be psychogenic in origin.

Second, there is an awareness that ventilation is difficult, and has increased excessively. This difficulty may be due to restrictive problems, or to obstructive impairment as in an asthmatic attack. Third, there is an awareness of the need for more ventilation, which occurs as with neuro-physiological problems and gives the discomfort which resembles the sensation felt at the end of a period of breath holding (Howell, 1966).

MacBryde (1970) stated that dyspnea causes a reduction in ventilatory capacity which is perhaps the most common disturbance in pulmonary function encountered among patients with various diseases of the lungs such as asthma. Dyspnea is invariably experienced by both normal individuals and in a variety of states when increased ventilation is required. Thus dyspnea is best defined as the subjective symptom which arises when the ventilatory apparatus is unduly taxed in meeting a certain requirement of the organism for ventilation. In order to appraise dyspnea adequately, it is necessary to establish the severity of the symptom, and the condition under which it occurs. All the evidences of the disability of the ventilatory function must be sought out to determine the degree of abnormality present (MacBryde, 1970, 327).

Dyspnea as Related to Emotions

Dyspnea is commonly found in patients with emotional problems even in the absence of organic disease, and recognition of its source may be difficult to obtain when anxiety or other emotional disturbances are present in the patient with organic disease (Rapaport, 1971).

As a result of a study done on twenty subjects, Dudley and his associates reported that dyspnea was found to be associated with both physiologic and psychologic changes. They also noted that dyspnea was associated with both hyperventilation and hyperpnea, and these were associated with anger and anxiety. They also reported some correlation of hypoventilation and decreased ventilation with depression (Dudley, 1968). In a study by Wolf and Holmes, referred to by Moore (1965) in her study, asthmatic patients were given inhalations of pollens to which they were sensitive. When the patients were relaxed and calm, they did not have an asthmatic reaction, but when they were made to feel resentful and angry, the same concentration of the pollens produced asthmatic attacks.

Emotional Responses to Asthma

The responses of the respiratory system to stress include an acceleration of rate and change in rhythm. Studies indicated that strong emotional responses accompany asthma, and that emotional responses are capable of influencing the airways of asthmatic subjects. Smith et al. (1970) described two women who while in a body plethysmograph had attacks of asthma induced during hypnosis. The authors found that when fear and anger were induced by hypnotic suggestion, asthma was produced. Hahn (1966) in reporting physiologic responses of twenty asthmatic children to

stress, used problem solving as the stimuli affecting the changes, and found that even though the children did not develop asthmatic symptoms, they did show significantly higher heart rate and skin temperatures.

Changes have been recorded in the status of the airways of asthmatics when presented with emotional stimuli, or when conditioned by stress as noted earlier. Studies have also shown changes indicating an increase in airway resistance in asthmatic subjects who inhaled neutral substances presented as stimuli producing bronchoconstriction (Dekker et al., 1956; Schiava, 1971; McFadden et al., 1972).

Knapp and Nemetz (1960) reported from a study of four hundred six acute asthmatic attacks that helplessness and hopelessness were frequently far out of proportion to the experience of the asthmatic attacks. They concluded that there were manifestations of tension, with a mixture of fear and irritability, even approaching a panic state. Knapp (1966) later studied the case history of a thirty three year old male asthmatic patient. It was noted that the psychological structure was melancholic, and the patient manifested attitudes of helplessness and dependency, and melancholia.

Kinsman et al., recently interviewed one hundred severe asthmatic subjects to rate the frequency with which certain subjective symptoms were experienced during acute asthmatic attacks. They found that five distinct symptom clusters could be identified from the results of the interviews done. Among those identified were two mood symptoms clusters, labeled "panic-fear" and "irritability" (Kinsman et al., 1972).

Tension in Asthma

Goldstein et al., (1964) reported that an individual tends to

respond to various stimuli consistently with his maximal level of response of tension in the same muscle, maintaining a consistent hierarchy of muscle tension. They found these principles to remain stable in each subject they studied.

Tension is produced primarily within the individual as a reaction to the environment. Excessive tension generally occurs as one reaction to stress. It may be difficult to control the amount of stress and tension in the everyday life, but it may be possible for the individual to exert some control over many of the physiological responses to stress and tension.

Subjects in asthmatic attacks often report experiencing a tight feeling in the chest, becoming more acute as they themselves become more tense and anxious as the struggle for air continues. Current research suggested that anxiety may be considered a term to represent the apprehension and resulting tension that accompany a heightened physiological arousal, such as the experience of an asthmatic attack. It has also been noted that relief of a patient's symptoms also relieves the tension and anxiety of the patient and those who surround him, whether at home or in the hospital environment (Wells et al., 1972).

Relaxation a Treatment for Asthma

The concept of relaxation as a coping response to lessen the physiological effects of stress and tension has received much investigation. Recently, extensive use has been made of voluntary muscle relaxation as a presumably inhibiting factor in anxiety. In an early work Reich (1945, 343) observed from clinical experience that it is evident

that muscular tension goes hand in hand with emotional problems, and he further observed that it is difficult to eliminate this tension unless something is substituted in its place. He therefore suggested that psychic tension and relaxation cannot be without somatic representation, for tension and relaxation are definite biophysical processes. He concluded that chronic increased muscle tension represents the individual's increased inhibitions, and he likened this to a muscular armor around the biological person, which protects it.

Wolpe (1956) stated that there is a state of reciprocal inhibition at work suppressing tension. This reciprocal response is antagonistic to tension and anxiety, and can be made to occur so that there may be a complete or partial suppression of the tension present. Relaxation training is one way of modulating or controlling tension, acting as a reciprocal inhibition. Sobel et al. (1973) noted that the first thing to be realized concerning relaxation and tension is that the individual is in control of his own tensions. Jacobson (1939) stated that the first step in relaxation training is learning to identify muscle tension, and he subsequently devised a set of relaxation exercises that would assist an individual to identify his own muscle tension and then learn to purposefully relax. The effects of progressive relaxation on physiological processes have been studied, and there have been reports of changes of blood pressure and heart rate (Jacobson, 1939; Love, 1972).

The effects of relaxation training on respiratory function have also been studied, and the results reported showed the following: decreases in airway resistance (Kinsman, 1972; Luparello, 1968). Increases in forced expiratory volumes in one second (Green et al., 1974;

Phillip et al., 1972), and increases in maximal peak flows (Alexander et al., 1972; Davis, 1973; Moore, 1965). In each of these studies relaxation training was introduced to the subjects and its effects on the bronchials were measured.

Biofeedback and Electromyography With Relaxation

Gaarder (1971) suggested that one of the most effective methods of controlling muscle tension involved the monitoring of proprioceptive feedback from the muscle system itself. The relaxation training could therefore be enhanced by the use of external feedback units.

The principles of biofeedback refer to detecting a physiological event and then converting the resulting electronic or transduced electronic signal into auditory or visual feedback. This technique can be integrated with certain procedures in behavior therapy such as relaxation training, to reinforce or modify the therapeutic results (Budzynski et al., 1972).

In most biofeedback studies done with animals, the reward for the behavior has been avoidance of an electrical shock, or electrical stimulation of the brain by implanted electrodes which the animals found rewarding (Miller, 1969; DiCara et al., 1970). In biofeedback studies done with human subjects, the intermediate reward or reinforcement for successful performance has been a light or sound signal. However, most investigators feel that for people, success itself is the true reinforcer, especially if the achievement may mean better health (Budzynski, 1970).

A general problem related to relaxation training with asthmatic subjects is the length of time it takes for the subjects to learn the

relaxation technique. Green et al. (1969) found that this could be remedied by a single feedback method. They found that seven out of twenty asthmatic subjects which they studied were able to achieve intermittent neuromuscular relaxation or lowering of tension level readings on an electromyograph. In a later study Green (1974) reported that the subjects they studied were not only able to relax subjectively, but they were also able to decrease their respiratory difficulties by increasing their forced expiratory volumes in one second.

The basis of electromyography is found in the cellular motor unit of contraction in skeletal muscle (Basmajian, 1963). As with any electrical signal, these summated motor unit potentials are picked up by the surface electrodes of the electromyograph, and demonstrated on its meter.

In summary, asthma has been considered by some investigators as a learned response to some stress situations. Anxiety and tension are increased as the asthmatic struggles for an uninterrupted passage of air through his lungs, and this added tension increases the struggle to get enough air into his lungs. It has been suggested in the literature that relaxation would counteract the effects of tension, and lessen the individual's struggle to breathe, or make the struggle more bearable. Biofeedback with electromyography has been found to be useful in increasing the subject's ability to learn to relax, and thus modifying his reaction to stress.

Chapter III

METHODOLOGY

This descriptive study was designed to determine the effects of relaxation training on six bronchial asthmatic subjects. To test the hypotheses, a base line was taken of the subjects' pulmonary function and tension levels, and the differences over the base line at the end of the study were noted to determine the effectiveness of the relaxation training intervention.

THE SAMPLE

The population from which the sample was taken consisted of bronchial asthmatic patients under the medical supervision of the Department of Chest Diseases at Loma Linda University Medical Center. The incidental or convenience sample of six individuals was selected irrespective of sex, from those subjects who were readily available. Treese and Treese (1973) stated that as a means of obtaining a representative sample, the researcher might use such subjects as were available, and all generalizations and conclusions from such sampling would have to be descriptive of the technique.

The sample was selected from persons between the ages of 14.0 and 70.0 years who met the following criteria:

a. Were willing to participate in the study,

b. Were diagnosed as bronchial asthmatics,

c. Were able to speak and understand the English language,

d. Had no known cardiac problems,

e. Had no other concomitant respiratory complications such as pneumonia, upper respiratory infections, or advanced emphysema.

Selection of the Subjects

The subjects meeting the specified criteria were selected by the physician who gave them an introduction to the purpose of the study. The nurse investigator then contacted each subject by phone, and an appointment was made to meet in a pre-study session. Twelve subjects were contacted after being referred by the physicians. Two of them decided that it was impossible for them to fit the study into their program, two of them had normal pulmonary function results when tested at the pre-session, and two dropped out of the study after beginning the first session. The length of time each subject was required to spend with the study contributed to the difficulty of securing an adequate sample, and many members of the population, though interested, did not find it convenient to participate in the study.

LABORATORY SESSIONS

Laboratory sessions in this study refer to those sessions which the subjects attended with the investigator in order to learn the technique of purposeful relaxation, using the biofeedback unit. These consisted of one pre-study session and eight regular sessions.

All the laboratory sessions were conducted in the main hospital building of the Loma Linda University Medical Center. The room was comfortably and modestly furnished, and was also used by other nurse investigators. There was a bed which was kept made up at all times, and

a comfortably built recliner chair. There were also a desk and secretary's chair, and six student type chairs which lined one side of the far wall. Beside the recliner there was a low table with a shaded lamp which was kept dimmed during the sessions, giving the room an atmosphere of relaxation.

The electromyograph and integrator instruments were placed on two small laboratory type tables at the convenience of the participant and the investigator. There were no pictures on the light, tan walls, and a mild colored green rug covered most of the floor space, complimenting the light colored walls and ceiling.

The investigator wore a white lab coat over street clothes. She sat obliquely behind the subject, who sat in the recliner during each of the relaxation training sessions.

The pre-study session. At the time of the pre-session, before the study was discussed, the nurse investigator introduced herself to the subject and explained her role in the study, which was defined to include data collection and offering of nurture and encouragement. The details of the study were discussed, and a consent form was signed as soon as it was evident that the subject understood the overall goals and objectives of the study, and indicated a willingness to participate.

The base line information was taken at this time. It consisted of recording the existing tension levels from the electromyographic readings, and the following pulmonary function tests: closing capacity and closing volume, forced expiratory volumes in one and three seconds, maximal mid-expiratory flow rate, functional residual capacity, forced vital capacity, and total lung capacity. These particular measurements

were chosen because they are considered more definitive for small airway and obstructive disease such as bronchial asthma.

All the pulmonary function tests were performed in the pulmonary function laboratory of the Loma Linda University Medical Center, and were performed by the laboratory personnel. The determinations reported were supervised by John Hodgkin, M.D., Chief of the Section of Medical Chest Diseases at the Loma Linda University School of Medicine.

The subjects were introduced to the relaxation exercises after the base line measurements were taken for pulmonary function and tension levels. The exercises were demonstrated and discussed to the subjects' satisfaction. The focus of the intervention was training in purposeful relaxation. The exercises were modifications of the techniques of Jacobson (1939) and Wolpe (1956). The exercises were designed to enable the subjects to consciously experience muscle tension, and to learn to be aware of its presence in the body. The subject was taught to be aware of the contrasting experience of relaxation to that of tension, and to desire the relaxation experience.

The exercises were systematically designed to begin at either body extremity, head or feet, and to advance in the opposite direction. At the end of the exercise session, the subject was instructed to repeat to himself the experience of relaxation as it was for him. The sensation which he felt might have been warmth, a tingling, or however he described it for himself.

A rest period of at least fifteen minutes was suggested at the conclusion of the exercises. When the exercises including the rest period were over, the subject was advised to rise slowly, rather than

hurriedly, from his resting position. The period of time spent with the exercises including the rest period of fifteen minutes, was thirty minutes.

Each participant was requested to practice the exercises at least twice each day during the time of the study. Times suggested were evenings before retiring to bed, and mornings before getting up to begin the day. The exercises included a stretching maneuver as demonstrated by Young (1950), who observed certain animals including cats, giving a stretching motion before going to sleep. She therefore included this stretching action in her relaxation training technique, concluding that stretching, followed by resting, illustrated the fact that a muscle or muscle group, stretched to its uppermost length, will return to its physiological resting position after the stretch is terminated. This leaves little or no tension remaining in the body. Jones (1953) also noted that yawning and stretching are two of the less involved methods of relaxing, and can be practiced even if the subject has neither time nor patience to practice a full set of relaxation exercises every day. (See Appendix F for exercises.)

General laboratory sessions. Appointments were made at the time of the pre-study session for attendance at the regular laboratory session of relaxation training. Two general sessions were held each week of the four-week study, making a total of eight sessions for each subject. The subjects were allowed three days to practice the relaxation exercises before they attended the first session. The appointments for the eight general laboratory sessions were set up primarily at the convenience of

the participants, at intervals of two to five days. The eight sessions were completed within a four-week period.

Each of the eight general laboratory sessions was designed to last forty-five minutes, and consisted of the relaxation training with the biofeedback unit and the collection of the tension levels data. The subject was greeted by the investigator and was given time to make himself comfortable before the session began. Ten minutes were allowed for these preliminaries before the electromyographic biofeedback session began, and ten minutes were allowed at the end for closing the session.

The biofeedback relaxation training sessions began after the subject stated that he was comfortable and ready to begin the session. While the subject was comfortably seated in the recliner chair, the area of the frontalis muscle was thoroughly cleansed with an alcohol sponge, and the surface electrodes were applied with electrode paste and adhesive tape. A few minutes were then given for the electrodes to gain maximum contact with the skin over the frontalis muscle, while the subject tried to make himself as comfortable as possible. If the subject was finding it difficult to relax, a few more minutes were given for him to try to do so.

After the subject had affirmed that he was comfortable and relaxed, the investigator said the following to him:

> If you are still feeling some tension anywhere in your body, make a stretching action, tensing as much of your body as is possible, adopting an attitude of hanging loose. Concerning your thoughts, adopt an attitude towards them of not being important at this time, and do not be concerned about them. Any plans for what you may have to do next, or tomorrow, can wait until later, after you have relaxed. This is your time to relax. In order for you to relax, you will have to concentrate so that you do not worry or think any anxious thoughts. Become aware of each part of your body, so that tension does not develop or remain anywhere in any part of your body.

The Biofeedback Unit

The Biofeedback Technology Inc. (BFT) 401 was the electrymyographic instrument used. This particular model was used in this study because it was conveniently available in the laboratory room. For feedback purposes the subject watched the electromyograph meter dial and noted the deflection of the meter needle. If the deflection was more to the right of the meter, the subject understood this to mean that he was maintaining an undesirable tension level in his body. It was an indication for him to practice purposeful relaxation. The other biofeedback device used was a tone connected to the electromyograph. When the subject's tension level was high, the tone rose in pitch and intensity, also indicating that the subject should further relax.

Collection of Tension Levels Data

The collection of the tension levels data took twenty-four minutes, and began after the electromyographic unit was tested and checked for battery strength and electrodes contact. The Biofeedback Technology Inc. (BFT) 215 was the integrator unit used to facilitate the data collection. It gave a readout in numbers for the mean of tension levels in two minute periods. A worksheet was used to record this data. (See Appendix A.) Three of these two-minute periods were grouped on the worksheet into six-minute readings, and four of these six-minute groups of readings were recorded in microvolts for each of the eight sessions.

LABORATORY METHODS FOR PULMONARY FUNCTION MEASUREMENTS

Airway resistance is always increased during an asthmatic attack, and may also be increased during symptom free periods. Airway resistance

was not directly measured in this study, but other measures were taken which would determine the presence and degree of airway obstruction in asthmatic subjects. The following were pulmonary function measurements taken in this study:

Closing capacity and closing volume. The measurement of closing volume has been found to provide a good indication of the peripheral or small airway disease present in the lungs. This measurement has been used to aid in the detection of small airway abnormalities. Closing volume is defined as that lung volume at which the dependent lung zones cease to ventilate, presumably as a result of airway closure (Craig et al., 1971; McCarthy et al., 1972).

The closing volume measurements in this study were done using the Ohio Nitrogen Analyzer Model 700, with the subject in the sitting position. This method consisted of having the subject expire maximally to full expiration. While the breath was being held, a bolus of nitrogen which the subject inspired was inserted into the mouthpiece. The subject then slowly made a vital capacity expiration over a period of ten to thirty seconds, while the nitrogen concentration in the expired gas and the volume of gas expired were continuously being measured and recorded.

The sample recording with the above maneuvers showed four discernable phases: (I) the dead space gas, (II) mixed alveolar and dead space gas, (III) an alveolar plateau, and (IV) a terminal and abrupt rise in the expired concentration of the nitrogen. This terminal phase in the expired concentration of the nitrogen represented the closing of the small airways, starting in the most dependent zones of the lungs, and moving progressively upward as the residual volume was approached.

The closing volume measurements were reported as closing volume ratio to the vital capacity, and the closing capacity ratio to the total lung capacity.

Spirometric Tests of Pulmonary Function

Forced expiratory volumes in one and three seconds, forced vital capacity and maximal mid-expiratory flow rate were the determinations made with an Electromed Spirometer. These were done with the subject in a sitting position. The spirometer was directly connected to the Loma Linda University Medical Center computer center, and the results for each measurement were therefore determined by computer.

The forced expiratory volumes in this study were obtained by having the subject breathe normally, and then take a deep breath on command. He was then instructed to exhale, forcing as much of the air out of his lungs as he possibly could. The amount of air expired in the first one second and three seconds were recorded for the data. The forced expiratory volume measures the volume of air that is expired by maximal effort in a specified time, and is reported as a percent of forced vital capacity. Forced vital capacity is a single breath volume which is expired as rapidly as possible.

The maximal mid-expiratory flow rate has been proposed as a simple and sensitive means for the detection of expiratory obstruction. Leuallen and Fowler (1955) studied patterns of flow rates in healthy persons and in subjects with obstructive diseases. They found a typical pattern of flow, rapid at first, and then progressively decreasing. They noted that those subjects studied with some pulmonary obstruction developed a relatively large rate of flow in the beginning of the expiration,

but were unable to maintain this rate of flow for the major part of the total expiration.

The observations noted above suggested that the middle part of the flow might be less effort dependent. It was concluded that a measurement of the middle fifty per cent of the total expiratory flow would increase the ability to detect expiratory retardation. The maximal mid-expiratory flow rate excludes the early volume of expired gas, the first twenty-five per cent, and the last part of the expired gas, the last twenty-five percent. This measurement then represents the flow rate at which the middle fifty per cent of the gas was expired.

Plethysmographic Tests of Pulmonary Function

The functional residual capacity, residual volume and total lung capacity reported in the data were measured using the method described by Dubois et al. (1956), the plethysmograph, or body box. This method is based on Boyle's law for compression of gases. The maneuvers were made with the subject in the sitting position. Volume change owing to the compression of gas inside the thorax was measured by equal and opposite small displacement of gas around the body inside the box. Appropriate calibrations were made, and after rebreathing the air of the chamber through a heated meter, the intrathoracic gas volume changes were converted mathematically (Butler et al., 1959).

The functional residual capacity is the volume of gas remaining in the lung at the resting expiratory level or end expiratory point in the respiratory cycle. This volume of gas, by remaining in the lungs at all times, prevents the lungs from collapsing to an airless state.

When airway resistance is increased as in asthma, the expiratory flow rates are decreased. Usually a bronchodilator is given and the tests are repeated. In the study, no bronchodilator was given.

The relaxation intervention was used with the subjects for four weeks consisting of eight sessions. At the end of the eight sessions, the subjects were again tested to note any changes in the pulmonary function test results, which would show the long-term effect of the relaxation training.

Testing for Results of Relaxation Training

Two interim testings were done for each subject. The same pulmonary function tests were used. The testing was done before and after each of the last two sessions, and the short term effects noted by the changes which occurred. On the days that the interim testing was done, the subject came in one hour before the session and had the pulmonary function test done. The tests usually took one hour. The subject then left the pulmonary function laboratory on the first floor of the building, took the elevator to the ninth floor and had the relaxation training session. After the session, the subject returned by elevator to the pulmonary function laboratory for the post session testing of the same pulmonary function tests taken before the session.

Long term testing. At the end of the eight relaxation training sessions, the pulmonary function tests were repeated. Appointments were made and the subjects came in some time during the same day or the day after the study was ended. No more than one day elapsed after the last relaxation training session of the study and before the end of the study

testing of pulmonary function. The pulmonary function tests were done at the convenience of the personnel in the pulmonary function laboratory.

End of study questionnaire. Some questions arose during the research study related to the subjective effects of the relaxation intervention. The subjects were not pre-tested, but a questionnaire was given to each one of the six participants in the study at the end of the last session. The purpose of this questionnaire was to collect data which would be representative of the subjective effects of the study. The six subjects were told that this was to determine any effect of the relaxation training which they had experienced as enabling them to do any of the following: to lessen their asthmatic symptoms in frequency and/or intensity, to abort an asthmatic attack, or to increase their activities of daily living to any degree.

The questionnaire included such areas of observation as the presence and intensity of the subjects' asthmatic symptoms, and the degree to which they cooperated in the study, as well as certain personal and environmental factors occurring during the course of the study. The subjects were also asked to what extent they thought that the relaxation intervention helped them to directly control their asthmatic symptoms. (See Appendix C for questionnaire.)

Anecdotal records. Anecdotal notes were made by the investigator during each of the relaxation training sessions for each of the six asthmatic subjects. In these notes were included the subject's appearance at the session, including whether he appeared tense or relaxed. The presence of any asthmatic symptoms was also recorded. The progress during

the session was noted, and any remarks made by the subject relative to his ability to relax during that session. Both negative and positive remarks were noted.

Chapter IV

PRESENTATION OF FINDINGS

The results of relaxation training on the airway resistance of six asthmatic subjects using myoelectric feedback were investigated in this study. The purpose was to discover whether an increased degree of body relaxation resulted in a decreased amount of respiratory resistance in the asthmatic subjects studied.

Description of Subjects and Variables

Five of the six subjects studied were female, and one male. Their ages ranged from 14.0 years to 70.0 years. This widely varying age range occurred because of the limited availability of subjects during the time the study was conducted. The subjects' histories of asthma were varied. Two of the six subjects experienced the first asthmatic attack in infancy, one in early childhood, one in early adulthood, and two later on in life. The only male in the study had the most recent onset of asthma, reporting his first asthmatic attack two years ago, in 1972. Table I, page 33, lists the descriptive information for each subject.

The medications which the subjects were taking during the study were of two kinds, bronchodilators and steroids. All six subjects were using some kind of machine for respiratory assistance at least twice each day during the study. Four of the six subjects used Bronchosol in the machine with their treatments, one used Isuprel and one used a plain cold steam nebulizer. Three of the subjects, numbers one, two, and six, were on decreasing dosages of prednisone.

Table I

DEMOGRAPHIC DATA FOR SIX ASTHMATIC SUBJECTS

Subject No.	Age In Years	Age of Onset	Sex	Height In Inches	Weight In Pounds	Occupation	History of Smoking
1	57.0	55.0	M	70.0	163.0	Storeowner	Never smoked
2	69.0	56.0	F	64.0	102.0	Housewife	Never smoked
3	13.5	0.5	F	64.0	202.0	Student	2 years
4	54.5	0.5	F	64.0	129.0	Nursery School Teacher	Never smoked
5	48.0	6.0	F	67.0	146.0	Housewife	Never smoked
6	44.0	25.0	F	65.0	120.0	Unemployed	Never smoked

Effects of Relaxation Training on Tension Levels

Tension levels were taken while the subject was on the electromyograph. On Table II, page 35, there is presented the tension levels for each of the six asthmatic subjects in the eight relaxation training sessions of the study. The highest level, the lowest level and the mean for each session are given. This shows the changes in tension levels within each session. During the sessions, many of the subjects had experienced episodes of coughing which caused their tension levels to be increased at those times when the coughing occurred. (See Appendix A for raw data.)

On the basis of individual sessions, each subject showed some reduction of his tension levels within each session. The difference in tension levels between the base line session and the last relaxation session was indicative of a reduction in tension levels for the six subjects. Subject No. 1 registered a mean of 6 microvolts in his base line session, and a mean of 2 microvolts in his last relaxation session. However, on his first relaxation session, he registered a mean of 42 microvolts, and for the sessions one through seven, he registered a mean of 26 microvolts. For the eighth session he registered a mean of 2 microvolts.

This pattern of tension reduction was similar for each of the six subjects. The mean of the base line session for all six subjects was 2.3 microvolts, and the mean for the last relaxation session for the six subjects was 2.4 microvolts. The highest mean of the highest tension level registered for all six subjects at the base line session was 9.0 microvolts, and 5.2 microvolts for the last session of the study.

There were many very low tension levels registered during the

Table II

HIGH, LOW AND MEAN TENSION LEVELS (IN MICROVOLTS) FOR EACH OF SIX ASTHMATIC SUBJECTS DURING EIGHT RELAXATION TRAINING SESSIONS

Relaxation Training Sessions		Subject Number						Mean Values
		1	2	3	4	5	6	
Pre Session	H	33	2	2	7	3	5	9.0
	L	4	1	1	1	2	1	1.7
	M	6	1	1	2	2	2	2.3
#1	H	42	2	20	4	3	25	12.8
	L	1	1	1	2	2	1	1.3
	M	42	2	11	2	2	8	11.2
#2	H	46	5	4	1	2	14	12.0
	L	1	2	2	1	1	3	1.7
	M	40	2	3	1	1	13	10.0
#3	H	20	8	120	1	22	31	33.9
	L	2	4	13	1	1	6	2.6
	M	10	6	92	1	11	18	22.3
#4	H	45	4	8	1	1	14	12.3
	L	2	2	4	1	1	5	2.5
	M	26	2	6	1	1	10	7.7
#5	H	40	25	3	39	5	6	19.7
	L	30	1	1	9	1	1	7.2
	M	28	4	1	21	1	3	9.7
#6	H	26	1	6	19	34	22	18.0
	L	1	1	1	9	1	6	3.2
	M	12	1	2	38	16	13	13.7
#7	H	2	5	8	9	2	12	6.3
	L	1	4	4	1	2	4	2.7
	M	1	4	6	2	2	7	3.3
#8	H	2	4	4	3	*	11	5.2
	L	1	1	1	1	*	2	1.2
	M	2	1	2	2	*	5	2.4

*Missed session

H = Highest, L = Lowest, M = Mean value in Session

sessions. The investigator began recording the mean values for the tension levels after the subject had relaxed initially for that session, and this was done for each of the six subjects for each of the eight laboratory relaxation training sessions. There were no apparent reasons for these very low values reported, except for the subjects' positive expectations of a technique which they saw as helping them to decrease their asthmatic problems.

Effects of Relaxation Training on Pulmonary Function

Base line pulmonary function tests were taken before the relaxation intervention began. The pulmonary function tests were also taken at two interim testing sessions and again at the end of the study. The purpose of the intervention was to determine whether an increased degree of total body relaxation would result in a decrease in respiratory difficulty as evidenced by the following: a decrease in closing capacity, closing volume and functional residual capacity, an increase in forced expiratory volume in one and three seconds, and an increase in maximal mid-expiratory flow rate.

The changes seen in the pulmonary function tests were not consistent, either in the interim testing or at the post-study testing. The following are the changes seen in each of the pulmonary function tests done, followed by a statistical description of the findings.

Closing capacity and closing volume. The closing capacity is reported as a ratio to the total lung capacity, and the closing volume is reported as a ratio to the vital capacity. These were decreased twenty per cent for the closing capacity ratio and increased eighteen per cent

for the closing volume ratio at the end of the study for subject number one. The interim tests for this subject showed for the first test a decrease in the closing capacity of five percent, and an increase in the closing volume of forty one per cent. The second interim testing showed increases of twenty and thirty per cent respectively for the closing capacity and closing volume ratios.

Subject number two showed decreases in both closing capacity and closing volume values over the prestudy testing and increases in both values for the two interim testing. Subject number three showed increases over the base line testing and in the second interim testing. Subject number four showed increases for the post study over the base line for both closing capacity and closing volume ratios, with the latter showing an increase of one hundred and twenty per cent. He was unable to complete the first interim testing, and showed an increase of ten per cent in the closing capacity, and a decrease of thirty five per cent for the second interim testing.

Subject number five showed decreases in both closing capacity and closing volume ratios over the base line, and increases in the closing capacity for the two interim testing, and decreases in closing volume ratios for both interim testing. Subject number six showed increases over the base line testing, and for the first interim testing.

Table III, page 38, shows the changes in the closing capacity, closing volume ratios for the six asthmatic subjects studied. The percentage of decrease or increase is also shown for each subject. In Appendix B are the records of the actual values for all the pulmonary function tests performed on each of the six subjects.

Table III

CHANGES IN *C.C. AND **C.V. FOR SIX ASTHMATIC SUBJECTS

Subject No.	Pre & Post Study		Interim Test I		Interim Test II	
	C.C./TLC	C.V./VC	C.C./TLC	C.V./VC	C.C./TLC	C.V./VC
1	Dec. 20%	Inc. 18%	Dec. 5%	Inc. 41%	Inc. 12%	Inc. 30%
2	Dec. 20%	Dec. 27%	Inc. 1%	Inc. 26%	Inc. 5%	Inc. 44%
3	Inc. 8%	Inc. 21%	Inc. 23%	Dec. 42%	Inc. 7%	Inc. 11%
4	Inc. 13%	Inc. 12%	Not Completed		Inc. 10%	Dec. 35%
5	Dec. 5%	Dec. 20%	Inc. 1.4%	Dec. 10%	Inc. 21%	Inc. 48%
6	Inc. 85%	Inc. 183%	Inc. 18%	Inc. 130%	Dec. 4%	Inc. 18%

*Closing Capacity is reported as a ratio to the total lung capacity

**Closing Volume is reported as a ratio to the vital capacity

Inc. = Increased

Dec. = Decreased

Forced expiratory volume in one second. Table IV, page 40, shows the changes indicated in the forced expiratory volumes in one and three seconds. These values are reported as ratios to the observed vital capacity for each subject.

Three subjects showed changes over the base line testing which indicated an increase in the forced expiratory volume in one second (FEV_1). They were subject number one, with an increase of thirty-seven per cent, subject number four with an increase of twenty per cent, and subject number six with an increase of four per cent. The other three subjects showed a decrease over the base line values. The measurements for each of the six subjects for the two interim testing showed both increases and decreases in the forced expiratory volume in one second within the sessions tested.

Forced expiratory volume in three seconds. The findings for the forced expiratory volume in three seconds (FEV_3) show the following changes when compared with the base line measurements:

Subject number one increased fourteen per cent; subject number four increased twenty-two per cent and subject number six increased four per cent. The other three subjects either showed a decrease over the base line, or remained the same, with the exception of subject number four, who was unable to complete her first interim testing session. For the most part, the findings for the interim testings showed decreases over the base line, or remained the same.

Functional residual capacity. Table V, page 41, shows the changes which occurred in the functional residual capacity over the base line and

Table IV

CHANGES IN *FEV_1 AND **FEV_3 FOR SIX ASTHMATIC PATIENTS

Subject No.	Pre and Post Study		Interim Test I		Interim Test II	
	FEV_1/VC	FEV_3/VC	FEV_1/VC	FEV_3/VC	FEV_1/VC	FEV_3/VC
1	Inc. 37%	Inc. 14%	No Ch.	No Ch.	Dec. 16%	Dec. 13%
2	Dec. 3%	Dec. 52%	Dec. 2%	Dec. 1%	Dec. 2%	Dec. 51%
3	Dec. 6%	Dec. 3%	Inc. 4%	Inc. 4%	Dec. 4%	Dec. 3%
4	Inc. 20%	Inc. 22%	Not Completed		Inc. 24%	Inc. 14%
5	Inc. 8%	Dec. 8%	No Ch.	Inc. 4%	Dec. 11%	Dec. 6%
6	Inc. 4%	No Ch.	Dec. 7%	Dec. 3%	Inc. 31%	Inc. 31%

*FEV_1 - forced expiratory volume in one second

**FEV_3 - forced expiratory volume in three seconds

VC - observed vital capacity

Inc. - Increased

Dec. - Decreased

No Ch. - No Change

Table V

CHANGES IN *FRC FOR SIX ASTHMATIC SUBJECTS

Subject No.	FRC		FRC		FRC	
	Pre Study	Post Study	Pre Session I	Post Session I	Pre Session II	Post Session II
1	1.18	1.18	1.11	1.02	1.18	1.18
2	0.85	0.85	0.85	0.85	0.85	0.85
3	0.92	0.92	0.92	0.92	0.92	0.92
4	1.32	Not comp.	1.32	1.32	1.32	1.32
5	0.93	1.08	0.93	1.08	1.08	1.08
6	1.08	1.08	1.08	1.08	1.08	1.08

*FRC - Functional Residual Capacity reported in liters

Not comp. - not completed

for the two interim testings. The values are reported for each subject in the study.

The following changes occurred in the functional residual capacity. The post study remained the same as the base line measurements for five subjects, and increased sixteen per cent for subject number five. The results of the interim testings also followed the same trend as the post study, with the exception of subject number one, who showed a decrease of eight per cent in the first interim testing, and subject number five showed an increase of sixteen per cent. There was no change for the second interim testing, except for subject number six, who showed a decrease of three per cent.

Forced vital capacity. Five of the six subjects tested showed an increase in the post study testing over the base line measurements. The other subject showed a decrease of nineteen per cent over the base line measurement of forced vital capacity.

The following changes resulted from the interim testings which were done for each subject. Subject number one showed a decrease of two per cent in the first test and an increase of six per cent in the second interim test. This was the only subject who showed an increase in the first interim testing. The other subjects each showed a decrease in their testing. Three subjects showed an increase and three showed a decrease in the second interim testing done. Table VI, page 43, shows the changes in forced vital capacity that occurred in the post testing when compared with the base line measurements. The changes which occurred for the two interim testings for each subject are also presented in the table.

Table VI

CHANGES IN *FVC FOR SIX ASTHMATIC SUBJECTS

Subject No.	Pre and Post Study FVC	Interim Test I FVC	Interim Test II FVC
1	Increased 27%	Decreased 20%	Increased 5%
2	Increased 19%	Decreased 3%	Increased 2%
3	Increased 7%	Increased 12%	Increased 7%
4	Decreased 19%	Was not completed	Decreased 14%
5	Increased 9%	Increased 15%	Decreased 7%
6	Increased 22%	Decreased 11%	Decreased 27%

*FVC - Forced vital capacity in liters

Maximal mid-expiratory flow rate. The findings for the maximal mid-expiratory flow rate show a decrease in the post study when compared with the base line measurements for all of the subjects except subject number one who showed an increase of fifty per cent over his base line measurement.

The changes for each of the six subjects showed that only subject number one had an increase in maximal mid-expiratory flow rate over the base line measurements. Each of the other five subjects showed a decrease. For the first interim testing, subjects number three and five showed increases in their maximal mid-expiratory flow rate, while subjects number one and two showed decreases, and subject number six showed no change. Subject number four was unable to complete the first interim testing.

For the second interim testing, only subject number four showed an increase, subject number six showed no change, and subjects number one, two and four all showed decreases.

Residual volume. Table VIII, page 46, shows the changes in residual volume for each of the six subjects. These changes occurred in the two interim testings, and in the post testing over the base line measurements.

The findings for the residual volume are reported as a ratio of the total lung capacity. Three of the subjects showed a decrease when the post study results were compared with the base line. The other three showed an increase over the base line.

For the first interim testing, subjects number three and five

Table VII

CHANGES IN *MMFR FOR SIX ASTHMATIC SUBJECTS

Subject No.	Pre and Post Study MMFR	Interim Test I MMFR	Interim Test II MMFR
1	Increased 50%	Decreased 16%	Decreased 48%
2	Decreased 47%	Decreased 9%	Decreased 58%
3	Decreased 14%	Increased 25%	Decreased 7%
4	Decreased 51%	Not Completed	Increased 40%
5	Decreased 22%	Increased 6%	Decreased 28%
6	Decreased 73%	No change	No change

*MMFR - Maximal mid-expiratory flow rate reported in liters per second

Table VIII

CHANGES IN *RV/TLC FOR SIX ASTHMATIC SUBJECTS

Subject No.	Pre and Post Study RV/TLC	Interim Test I RV/TLC	Interim Test II RV/TLC
1	Decreased 3%	Decreased 12%	Increased 4%
2	Decreased 21%	Decreased 8%	Decreased 4%
3	Increased 1%	Increased 36%	Increased 3%
4	Increased 2%	Not Completed	Increased 1%
5	Decreased 15%	Increased 61%	Increased 7%
6	Increased 11%	Decreased 5%	Decreased 10%

*RV/TLC - Ratio of residual volume to total lung capacity

showed an increase, subjects number one, two and six showed a decrease, and subject number four was unable to complete the testing.

Total lung capacity. The measurements for the total lung capacity showed that three subjects had an increase over the base line measurements in the post test. Subject number three showed the greatest increase of twenty-seven per cent over her base line.

The findings of the two interim testings for each of the six subjects showed that three subjects had an increase in each of the testings. Subject number three had the greatest increase in the first test and subject number two had the greatest increase in the second test.

Table IX, page 48, shows the changes which occurred for both the post testing and the two interim testings for the six subjects.

Responses to end of study questionnaire. A questionnaire was given to each subject at the end of the last session. This was in order to determine what, if any subjective changes had taken place in the patients as a result of the study. The questionnaire was concerned with the subjects' asthmatic symptoms, the factors that trigger or intensify these symptoms, their faithfulness in practicing the relaxation exercises, and specific benefits which they felt that they had received as a direct result from their participation in the study.

The questionnaire and an analysis of the answers given are to be found in Appendix C. The following is an analysis of the answers given to the questionnaire by the six asthmatic subjects in the study.

Factors that contribute to asthma-related symptoms. Four subjects stated that pollens and heavy smog contributed to their asthmatic attacks,

Table IX

CHANGES IN *TLC FOR SIX ASTHMATIC SUBJECTS

Subject No.	Pre and Post Study TLC	Interim Test I TLC	Interim Test II TLC
1	Increased 4%	Decreased 8%	Increased 1%
2	Decreased 9%	Increased 1%	Increased 6%
3	Increased 27%	Increased 15%	Decreased 1%
4	Decreased 8%	Not completed	Decreased 3%
5	Decreased 2%	Increased 8%	Increased 2%
6	Increased 1%	Decreased 1%	Decreased 2%

*TLC - total lung capacity

Two mentioned cold air, and two listed excessive exercise, and two other subjects listed emotional factors as contributing to their asthmatic symptoms. The only male subject in the study stated that he had not been able to identify any particular factor or set of factors which contributed in any way to his asthma.

Specific asthmatic symptoms that subjects experienced. All six subjects said that they experienced coughing and a tight feeling in the chest. Four of the six subjects stated that they experienced wheezing. These were the symptoms which the subjects stated were triggered or intensified by the factors mentioned above.

Practice of the relaxation exercises. This question was formulated to determine the degree of cooperation of the subjects by their practice of the relaxation exercises as they were instructed to do in the study. Four of the subjects reported practicing the exercises faithfully twice each day as the study required. One subject stated practicing the exercises once each day, and one subject reported practicing the exercises infrequently.

Benefit of biofeedback with relaxation training. The biofeedback unit used in the study included the visually available dial on the electromyograph and a tone whose intensity and pitch were increased when the tension levels of the subjects were increased. Four of the six subjects found this unit beneficial in helping them to reduce their tension levels during each of the eight sessions of the study. One subject found the biofeedback unit useful many times during the sessions, and one found it useful only some of the time.

The next three sections of the questionnaire dealt with the benefits that the subjects might have received from the participation in the study.

Ability to relax increased. Since participating in the study, one subject reported being frequently able to relax. Three subjects reported being able to relax only occasionally, one reported seldom being able to relax, and one subject stated that he had never learned to relax.

Activities of daily living increased. One subject reported being able to walk longer distances since participating in the study. Four subjects reported being able to carry on their regular activities of daily living for longer periods of time, and four subjects also reported being able to fall asleep easier and faster than before participating in the study. One subject reported seeing no change.

Decreased frequency of symptoms. The asthmatic symptoms reported to be relieved the most by all six subjects was the tight feeling in the chest. All six subjects reported a general decrease in their asthmatic symptoms which they experienced before taking part in the study. Table X, page 51, contains the overall subjective findings, showing directional changes in the subjects' ability to relax, and to carry out activities of daily living, and changes in their asthmatic symptoms and tension levels.

Statistical Analysis of Data

In a statistical analysis of the data, the changes in pulmonary function testing results were treated with two statistical tests to

Table X

OVERALL FINDINGS OF TENSION LEVELS AND SUBJECTIVE FINDINGS FOR SIX ASTHMATIC SUBJECTS

Subject No.	Age	Sex	Occupation	Overall Tension Levels	Subjective Findings From Questionnaire			
					Practiced Exercises	Ability to Relax	Changes in Symptoms	Changes in Activity of Daily Living
1	57	M	Store Proprietor	Decreased	*Twice Daily	Increased	Decreased	Increased
2	69	F	Housewife	Decreased	Once Daily	Increased	Decreased	Increased
3	14	F	Student	Decreased	Infrequently	Not Completely	Decreased	Increased
4	55	F	Nursery Teacher	Decreased	Twice Daily	Increased	Decreased	No Change Noted
5	48	F	Housewife	Decreased	Twice Daily	Increased	Decreased	Increased
6	44	F	Housewife	Decreased	Twice Daily	Increased	Decreased	Increased

*Each subject was instructed to practice the exercises twice each day.

determine whether any significant differences were present. Long term changes between the base line, or pre-study, and the post study were treated with a T test for paired differences, and the associated probability levels for these differences were determined. This showed no significance for any of the pulmonary function tests from base line to the end of the study.

Short term changes seen in the two interim testings were treated with a two-way analysis of variance to show (1) whether the changes were due to any significant interaction between the sessions or (2) whether they were due to interactions among the subjects.

In the two-way analysis of variance, significant differences in the following pulmonary function tests were seen between the two interim testing sessions for the group of six subjects: closing capacity/total lung capacity, P value, <.02; and forced vital capacity, P value, <.008. However, the mean values for these two testings did not change in the direction which was hypothesized, but in the opposite direction. The two-way analysis table for the closing capacity/total lung capacity is found in Appendix H.

Variability among the subjects themselves between the two interim testing sessions was significant for the following pulmonary function tests: forced expiratory volume in one second (FEV_1), P value <.001; forced expiratory volume in three seconds (FEV_3), P value <.0001; functional residual capacity (FRC), P value <.0001; maximal mid-expiratory flow rate (MMF), P value <.02, and residual volume/total lung capacity (RV/TLC), P value <.0001.

The analysis of variance did not give information as to whether

the differences among the subjects were due to the independent variable (relaxation training), or to other unquantified variables which may have influenced the pulmonary function testing results.

Chapter V

DISCUSSION OF FINDINGS, SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

It was hypothesized in this study that the lower the tension levels, the more relaxed the asthmatic subject would become, and therefore, the less respiratory difficulties he would experience. This would be evidenced by certain directional changes in selected pulmonary function tests. There was evidence in the literature reviewed, that total body relaxation could be achieved by autogenic relaxation training with the use of electromyographic biofeedback. The two questions, therefore, to be answered by the findings in this study were, (1) were the six asthmatic subjects in the study able to relax, and did they achieve a lowered level of total body tension, and (2) were there changes in the pulmonary function tests which indicated a correlation with the subjects' ability to purposefully relax.

In exploring how these questions were answered by the findings of the study, the following discussion was presented, and includes factors which may have influenced the results of the study.

Changes in Tension Levels

There was noticeable lowering of the total body tension levels within each of the eight sessions for each of the six subjects in the study. However, subject number one was the only subject whose tension level results showed a decrease when the mean of the base line session was compared with the mean of the last session of the study. Many of

the subjects registered very low integrated tension levels for the base line session, and for the early relaxation training sessions. Many of these values were as low as one or two microvolts. It should be noted that peak microvolt values are two to three times the integrated reading. A possible reason for these low integrated values which were registered so early in the study might have been the subjects' anticipation of positive results from the study.

There were some factors observed in the study which could have been responsible for the tension levels recorded for the subjects. Some of these factors were related to the subjects themselves. Some factors were related to the investigator's choice of the study design, and other factors were related to variables which were either difficult or impossible to control in the study.

Factors related to the subjects. According to the anecdotal records, a spasm of coughing frequently occurred during the relaxation training sessions when the tension levels were being measured. The subjects stated that these outbursts of coughing were caused when they tried to suppress an earlier urge to cough. When these coughing episodes occurred, the subjects became more tense, and their tension levels became increased. Because of these coughing spasms, the tension levels were often higher during some portion of the relaxation training session than at the beginning of that session. Many times the subjects were able to control the coughing, relax, and reduce the high tension levels incurred by the coughing episode before the end of that training session.

There were other factors present which affected the tension levels. Some of these were the physiological factors which were related

to the subjects' asthma, and some were related to the environmental and emotional factors which stimulated the subjects' asthmatic symptoms. The physiological factors include the amount of mucous production within the bronchioles, and the subjects' ability to dispose of this mucous obstruction. Other physiological factors were related to the general physical condition of the subjects.

The environmental factors affecting the subjects' asthmatic symptoms included the presence of pollens and heavy smog during the four weeks of the study. There were a number of emotional factors affecting the subjects' ability to relax, over which the investigator had no control. Many of these factors were identified by the subjects during the course of the study as being personal in nature. One such factor was the robbery of a subject's store.

Factors related to the design of the study. Those factors which affected the findings reported, and which were identified as being related to the design of the study were the following: the length of the study, the number of relaxation training sessions in which the subjects were supposed to learn the technique of purposeful relaxation, the distance the subjects had to travel between their residences and the laboratory room, and between the laboratory room and the pulmonary function laboratory, and the lack of supervision of the subjects' practice of the relaxation exercises.

The length of time designed for the study could have been a limiting factor in the subjects' ability to learn the technique of purposeful relaxation, and develop the ability to use it effectively to

reduce their tension levels. The number of biofeedback relaxation training sessions were set at eight sessions for each of the six subjects. This determination was based initially on the reports of other investigators' experience as the minimum number of sessions in which it was anticipated most subjects could learn the relaxation technique.

The design of the study did not make any provision for the supervision of the subjects' practice of the relaxation exercises at any time during the study. The exercises were demonstrated for the subjects at the beginning of the study, and they were instructed to practice the exercises at least twice each day, once in the morning and again in the evening. The actual practicing of the exercises was left up to the subjects' motivation to participate in the study.

Other factors affecting tension levels. One of the uncontrollable variables in the study was the distance which the subjects had to travel in order to attend the biofeedback training sessions at the Loma Linda University Medical Center Hospital building. The shortest distance any one subject traveled was six miles, and the longest distance was forty to fifty miles. Traveling over these distances included driving an automobile to make the visit twice each week, and involved the tensions that are ordinarily experienced with traffic on the freeways.

Changes in Pulmonary Function Tests

The findings of the pulmonary function tests results did not show the hypothesized directional changes. The particular pulmonary function tests done in this study were selected to indicate changes in small airway caliber that would be beneficial to the asthmatic subject. Tests

were done to determine the long term effects (over the four weeks period), and short term effects (before and after each of the last two sessions) of the purposeful relaxation training. According to the findings reported in the study, the differences seen in either the long term or short term testing results did not support the hypothesis of the study.

Factors Affecting Pulmonary Function Tests

There were some factors other than the independent variable of relaxation training which could have influenced the pulmonary function testing results. Some uncontrolled variables such as those factors affecting the subjects' asthmatic symptoms could have influenced the pulmonary function tests results. These were the same factors mentioned as affecting the tension levels registered for each subject. These factors included emotional and environmental factors, and those factors related to the design of the study, such as the long distances which the subjects covered to reach the laboratory room for the relaxation training.

Each of the six subjects reported to the investigator on several occasions that the pulmonary function testing procedures were very stress-producing for them. Phillip et al. (1972) suggested in their study that the use of the nose clip, the insertion of the mouth piece and the forced breathing required in the respiratory function tests all detracted from the relaxation process, and produced decreases in respiratory function when increases were expected. Butler (1959) reported that forced breathing in asthmatic subjects may increase the functional residual capacity (FRC) instead of decreasing it as was hypothesized in this study.

Most of the subjects showed slight increases in the measurements used to determine airway resistance for the post study testing over the

base line measurements before the study began. It was possible that the subjects were either unable to utilize the relaxation technique, or that the relaxation process was interrupted by the post session pulmonary function testing. An alternate possibility was that the increased total body relaxation did not alter airway resistance at all, and that factors not controlled in the study design may have influenced the pulmonary function tests results. However, it must also be considered that at the time of increased total body relaxation, airway resistance may be increased in some asthmatic subjects instead of being decreased as was hypothesized in this study.

It was also possible that the respiratory status of the six asthmatic subjects was already stabilized, and that the relaxation training would not have helped their asthmatic problems very quickly or dramatically enough during the course of the study to affect the physiological respiratory changes hypothesized.

Subjectively, all six subjects reported having been able to breathe easier as a result of the relaxation training. However, changes seen in the pulmonary function tests did not give any objective support to these reports. It was possible that the highly subjective component in the dyspnea experienced in asthma may have been altered more by the relaxation training than the physiological factors which were measured by the pulmonary function tests selected.

Subjective Findings of the Study

The subjective findings reported in the end of study questionnaire all show results which tend to support the general hypothesis of

the study. The subjects who reported practicing the exercises as they were instructed, also indicated that they had been able to achieve some amount of total body relaxation. They also reported that their asthmatic symptoms were decreased in frequency and intensity as a result of their learned ability to purposefully relax. The one subject who reported that she did not practice the relaxation exercises as frequently as was instructed, also reported that she had learned to relax sufficiently to decrease her asthmatic symptoms and to abort a full-blown attack of asthma.

Each of the six subjects reported that they had learned to purposefully relax, and to reduce their asthmatic symptoms. Two of the six subjects felt that their conscious efforts to relax had enabled them to abort some asthmatic attacks. Dyspnea was one very common subjective symptom experienced by each of the six asthmatic subjects. Each subject reported that he could have used the technique of purposeful relaxation to overcome the sensations of breathlessness. This reportedly helped them in controlling their asthma.

This data suggested several possibilities. Either the stress related to forced breathing in the respiratory function testing procedures in some way interfered with the relaxation process, or perhaps there are no objective pulmonary physiological correlates with purposeful relaxation. However, the subjective findings did suggest that there might be a correlation of the subjects' psychological attitudes with the relaxation training, thus affecting a subjective respiratory symptom such as dyspnea.

Implications for Nursing

The subjective findings in the study indicated that the subjects

were able to reduce the frequency and intensity of their asthmatic symptoms as a result of having learned to purposefully relax. This presents the possibility of including relaxation training training techniques in the nursing care plan of asthmatic patients. The objective changes seen in the pulmonary function tests did not show the physiological results desired in the study; however, the subjects' ability to cope more effectively with their asthma after the relaxation training sessions suggested that nurses should explore the value of teaching relaxation techniques to asthmatic patients.

SUMMARY OF FINDINGS

The six asthmatic subjects in this exploratory study did not significantly reduce their total body tension levels over the base line measurements taken before the study began. Some reduction of tension levels was noted within each of the eight relaxation sessions.

Pulmonary function testing results did not show that the six subjects were able to decrease their airway resistances as was hypothesized. Many variables which were not controlled in the study were suggested as possible factors acting upon the subjects to influence the results of the pulmonary function tests.

A questionnaire was given to each of the subjects at the end of the study. Subjective findings from this questionnaire showed that subjects who practiced the exercises felt that they had learned to relax and to decrease their total body tension level. All of the six subjects stated that they had learned to relax to some degree, and that their respiratory difficulties were decreased as a result of their participation in the relaxation training study.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The hypothesis of the study that a lowering of the degree of total body tension level would result in a decrease in airway resistance for the six asthmatic subjects as demonstrated by directional changes in the following sub-hypotheses was not supported.

1. The difference between the means of the closing capacity (CC) and the closing volume (CV) taken before and after the relaxation training would show a decrease.

2. The difference between the means of the forced expiratory volumes in one (FEV_1) and three seconds (FEV_3) taken before and after the relaxation training would show an increase.

3. The difference between the means of the functional residual capacity (FRC) taken before and after the relaxation training would show a decrease.

4. The difference between the means of the forced vital capacity (FVC) taken before and after the relaxation training would show an increase.

5. The difference between the means of the maximal mid-expiratory flow rates (MMF) taken before and after the relaxation training would show an increase.

6. The difference between the means of the residual volume (RV) taken before and after the relaxation training would show a decrease.

Subjective findings from the end of study questionnaire generally supported the hypothesis that a decreased degree of total body tension

levels would result in a decrease in respiratory difficulties for the six asthmatic subjects. These findings showed that the subjects were able to relax and decrease their asthmatic symptoms both in frequency and intensity.

Recommendations

This exploratory study involving the technique of purposeful relaxation with asthmatic subjects has provided some base line information from the six subjects studied. It was therefore recommended that further studies be done with relaxation training and asthmatic subjects, and that the following recommendations be considered in the areas of sampling, methodology, and nursing interventions with asthmatic patients.

Sampling recommendations. The recommendations in the area of sampling include the following:

1. Selecting a larger sample of subjects, using a random method of selection, and allowing for a longer period of time for the selection of the subjects.

2. Screening the asthmatic subjects selected in order to decrease the amount of variability that was present between subjects in this study.

3. Accepting for the study only those subjects who would be able to maintain a relatively stable medication regimen.

Methodology recommendations. The recommendations which relate to the methodology include the following:

1. The use of a control group from the population, meeting the same criteria as the sample.

2. The administration of psychological tests that would measure the anxiety state of the subjects before and after each relaxation training session, and correlating the results of these tests with the results of the electromyographic measurements.

3. The supervision of the practice of the relaxation exercises by the investigator before each relaxation training session.

4. The use of a single easily administered measure of respiratory resistance such as an oscillator resistor which would be desirable if such equipment could be obtained.

Nursing intervention with asthmatic patients. It is recommended that a descriptive study be conducted with asthmatic patients to explore the feasibility of teaching them purposeful relaxation techniques during incidental nursing encounters.

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APPENDIX A

APPENDIX A

WORK SHEETS AND RAW DATA FOR TENSION LEVELS IN MICROVOLTS FOR SIX ASTHMATIC SUBJECTS

Name_____ Subject # 1

No. of Session	Average for Four Six Minutes Periods					Remarks
	1st	2nd	3rd	4th	Mean	
Pre Session	9	6	4	6	6	
1	42	42	42	42	42	
2	38	44	46	32	40	
3	20	5	4	10	10	
4	22	27	30	26	26	
5	40	35	34	36	28	
6	25	20	4	1	12	
7	2	1	1	1	1	
8	2	2	2	2	2	

APPENDIX A

WORK SHEETS AND RAW DATA FOR TENSION LEVELS IN MICROVOLTS FOR SIX ASTHMATIC SUBJECTS

Name_____ Subject # 2

No. of Session	Average for Four Six Minutes Periods					Remarks
	1st	2nd	3rd	4th	Mean	
Pre Session	2	1	1	1	1	
1	2	2	2	2	2	
2	2	3	2	2	2	
3	5	5	7	6	6	
4	2	2	2	3	2	
5	1	10	2	2	4	
6	1	1	1	1	1	
7	5	4	4	3	4	
8	1	2	1	2	1	

APPENDIX A

WORK SHEETS AND RAW DATA FOR TENSION LEVELS IN MICROVOLTS FOR SIX ASTHMATIC SUBJECTS

Name_____ Subject # 3

No. of Session	Average for Four Six Minutes Periods					Remarks
	1st	2nd	3rd	4th	Mean	
Pre Session	1	2	1	1	1	
1	20	14	10	1	11	
2	4	3	2	2	3	
3	120	193	44	13	92	
4	8	7	5	4	6	
5	3	1	1	1	1	
6	4	3	1	2	2	
7	5	5	6	9	6	
8	4	2	1	1	2	

APPENDIX A

WORK SHEETS AND RAW DATA FOR TENSION LEVELS IN MICROVOLTS FOR SIX ASTHMATIC SUBJECTS

Name_____ Subject # 4

No. of Session	Average for Four Six Minutes Periods					Remarks
	1st	2nd	3rd	4th	Mean	
Pre Session	1	1	1	1	1	
1	3	2	2	2	2	
2	1	1	1	1	1	
3	1	1	1	1	1	
4	1	1	1	1	1	
5	36	17	13	18	21	
6	33	40	36	45	38	
7	1	2	1	4	2	
8	2	3	1	1	2	

APPENDIX A

WORK SHEETS AND RAW DATA FOR TENSION LEVELS IN MICROVOLTS FOR SIX ASTHMATIC SUBJECTS

Name_____ Subject # 5

No. of Session	Average for Four Six Minutes Periods					Remarks
	1st	2nd	3rd	4th	Mean	
Pre Session	2	2	3	2	2	
1	2	2	2	2	2	
2	1	1	1	1	1	
3	13	18	22	18	11	
4	1	1	1	1	1	
5	3	1	1	1	1	
6	28	32	1	2	16	
7	2	2	2	2	2	
8	M I S S E D					

APPENDIX A

WORK SHEETS AND RAW DATA FOR TENSION LEVELS IN MICROVOLTS FOR SIX ASTHMATIC SUBJECTS

Name_____ Subject # 6

No. of Session	Average for Four Six Minutes Periods					Remarks
	1st	2nd	3rd	4th	Mean	
Pre Session	5	4	1	3	4	
1	1	8	13	11	8	
2	10	6	3	6	13	
3	17	13	9	13	18	
4	9	8	9	9	10	
5	3	4	1	8	3	
6	22	7	7	12	13	
7	8	7	8	8	7	
8	4	4	4	4	5	

APPENDIX A

WORKSHEET FOR EACH SESSION WITH ELECTROMYOGRAPHIC TENSION LEVEL

Date_____ Session #_____

Name_____ Subject #_____

Six Minutes Periods	Integrator Mean for Each of Three Two Minutes Periods			Average for Minutes
	1st	2nd	3rd	

Anecdotal Note:

APPENDIX B

APPENDIX B

PULMONARY FUNCTION TESTS RESULTS FOR SIX ASTHMATIC SUBJECTS IN RELAXATION TRAINING

Subject #1

Sessions	FVC	FEV_1/VC	FEV_3/VC	MMF	TLC	FRC	RV/TLC	CC/VC	CC/TLC
Pre Study Tests									
Pre Bronchodilator	.96	.59	.73	0.15	0.15	1.18	1.14	1.80	1.52
Post Bronchodilator	1.26	.77	.85	.43					
Interim Testing									
Session I									
Pre Session	1.30	.85	.88	.53	1.15	1.11	.93	1.04	1.16
Post Session	1.04	.85	.88	0.44	1.06	1.02	.82	1.47	1.22
Session II									
Pre Session	1.15	.96	.95	.74	1.18	1.18	.78	1.12	1.09
Post Session	1.22	.81	.83	.38	1.18	1.18	.81	1.46	1.22
Post Study Tests									
Pre Bronchodilator	1.22	.81	.83	.38	1.20	1.18	.81	1.46	1.22
Post Bronchodilator	1.25	.91	.93	.75					

APPENDIX B

PULMONARY FUNCTION TESTS RESULTS FOR SIx ASTHMATIC

SUBJECTS IN RELAXATION TRAINING

Subject #2

Sessions	FVC	FEV_1/VC	FEV_3/VC	MMF	TLC	FRC	RV/TLC	CC/VC	CC/TLC
Pre Study Tests									
Pre Bronchodilator	.92	.66	.78	.19	1.06	.85	1.02	1.08	1.02
Post Bronchodilator	.98	.75	.85	.29					
Interim Testing									
Session I									
Pre Session	1.27	0.79	0.82	0.33	0.94	.85	.84	.75	.92
Post Session	1.23	0.77	.81	.30	.95	.85	.77	.95	.93
Session II									
Pre Session	1.08	0.65	.76	.24	.92	.85	.83	.55	0.85
Post Session	1.10	0.64	.37	.10	.97	.85	.80	.79	0.90
Post Study Tests									
Pre Bronchodilator	1.10	0.64	.37	.10	.97	.85	.80	.79	.90
Post Bronchodilator	1.19	.77	.83	.32					

APPENDIX B

PULMONARY FUNCTION TESTS RESULTS FOR SIX ASTHMATIC SUBJECTS IN RELAXATION TRAINING

Subject #3

Sessions	FVC	FEV_1/VC	FEV_3/VC	MMF	TLC	FRC	RV/TLC	CC/VC	CC/TLC
Pre Study Tests									
Pre Bronchodilator	1.15	1.03	1.02	.62	1.11	.92	.94	3.41	2.12
Post Bronchodilator	1.12	1.04	1.01	.82					
Interim Testing									
Session I									
Pre Session	0.93	0.89	0.98	0.36	.74	.92	1.04	1.34	1.80
Pre Session	1.04	.93	.99	.45	.85	.92	1.42	.78	2.21
Session II									
Pre Session	1.0	1.01	1.02	.57	.83	.92	.92	3.65	2.15
Post Session	1.07	.97	.99	.53	.82	.92	.95	4.15	2.30
Post Study Tests									
Pre Bronchodilator	1.07	.97	.99	.53	.82	.92	.95	4.15	2.30
Post Bronchodilator	1.03	1.03	1.00	0.58					

APPENDIX B

PULMONARY FUNCTION TESTS RESULTS FOR SIX ASTHMATIC

SUBJECTS IN RELAXATION TRAINING

Subject #4

Sessions	FVC	FEV_1/VC	FEV_3/VC	MMF	TLC	FRC	RV/TLC	CC/VC	CC/TLC
Pre Study Tests									
Pre Bronchodilator	1.00	0.60	0.68	0.43	1.23	1.32	1.29	.59	1.30
Post Bronchodilator	1.03	0.67	0.80	0.21					
Interim Testing									
Session I									
Pre Session	0.98	0.61	0.74	0.15	1.16	1.32	1.21	1.37	1.42
Post Session	Subject was not able to complete test								
Session II									
Pre Session	.94	.58	.73	.15	1.18	1.32	1.30	2.14	1.64
Post Session	.81	.72	.83	.21	1.14	1.32	1.31	1.30	1.47
Post Study Tests									
Pre Bronchodilator	.81	.72	.83	.21	1.14	1.32	1.31	1.30	1.41
Post Bronchodilator	.98	.64	.79	.20					

APPENDIX B

PULMONARY FUNCTION TESTS RESULTS FOR SIX ASTHMATIC

SUBJECTS IN RELAXATION TRAINING

Subject #5

Sessions	FVC	FEV_1/VC	FEV_3/VC	MMF	TLC	FRC	RV/TLC	CC/VC	CC/TLC
Pre Study Tests									
Pre Bronchodilator	1.28	0.77	0.89	.45	1.25	0.93	0.72	0.98	0.97
Post Bronchodilator	1.35	0.91	0.94	.67					
Interim Testing									
Session I									
Pre Session	1.52	.75	.82	.36	1.17	.93	.46	1.60	.99
Post Session	1.36	0.75	0.85	0.38	1.26	1.08	0.74	1.44	1.13
Session II									
Pre Session	1.55	.87	.93	0.65	1.26	1.08	0.65	1.27	1.02
Post Session	1.44	0.77	0.87	0.46	1.29	1.08	0.70	1.88	1.24
Post Study Tests									
Pre Bronchodilator	1.39	.71	0.82	.35	1.23	1.08	0.61	1.08	0.92
Post Bronchodilator									

APPENDIX B

PULMONARY FUNCTION TESTS RESULTS FOR SIX ASTHMATIC SUBJECTS IN RELAXATION TRAINING

Subject #6

Sessions	FVC	FEV_1/VC	FEV_3/VC	MMF	TLC	FRC	RV/TLC	CC/VC	CC/TLC
Pre Study Tests									
Pre Bronchodilator	0.46	0.57	0.76	0.38	0.92	1.08	1.14	1.0	1.85
Post Bronchodilator	0.59	0.56	0.80	0.44					
Interim Testing									
Session I									
Pre Session	0.70	0.55	.71	.10	.91	1.08	1.39	1.24	1.60
Post Session	0.62	0.51	.69	.10	.90	1.08	1.29	2.90	1.88
Session II									
Pre Session	0.77	0.45	0.61	0.10	0.96	1.12	1.40	2.78	1.92
Post Session	0.56	0.59	0.76	0.10	0.94	1.08	1.26	2.83	1.85
Post Study Tests									
Pre Bronchodilator	0.56	0.59	0.76	0.10	0.94	1.08	1.26	2.83	1.85
Post Bronchodilator									

APPENDIX C

APPENDIX C

END OF STUDY QUESTIONNAIRE

AND ANALYSIS OF RESULTS

1. The following factor(s) that I feel contribute most to the precipitation of my asthma attacks
   a. Pollens
   b. Cold air
   c. Heavy smog
   d. Excessive exercise compared to my normal activity
   e. Emotional factors
   f. None of the above. If this answer is yes, please state what does. _____.
2. The symptom(s) that I experience most frequently before a full blown attack of asthma comes on is (are)
   a. Coughing
   b. Wheezing
   c. A tight feeling in my chest
   d. All of the above
   e. None of the above. If this answer is yes, please state what does. _____.
3. I was able to relax and avoid a full blown attack of asthma since joining the asthma project
   a. Frequently
   b. Occasionally

c. Seldom

d. Never

e. If your answer is a, b, or c., please state the circumstances.

_____.

4. The symptom(s) that I experience less frequently or in lesser amounts and intensity due to my learned ability to relax is (are)

a. Coughing

b. Wheezing

c. Tight feeling in my chest

d. All of the above

e. None of the above.

f. If the answer is a, b, or c, please state the circumstance(s).

_____.

5. The complete set of exercises designed to teach me relaxation was practiced

a. Twice each day as was suggested during the length of my participation in the project.

b. Once each day in the morning before getting up

c. Once each evening before going to bed

d. Not practiced as frequently as above

e. If the answer is none of the above, please state how frequently the exercises were practiced. _____.

6. I was able to practice parts of the set of exercises during various times of the day as I felt the need to learn to relax

a. Some part of every day apart from my regular practice times

b. Not every day, but sometimes

c. Never

7. I found the biofeedback unit with the audio tone and intensity very beneficial in helping me to recognize my tension levels during regular laboratory sessions

   a. At all times when I attended the sessions

   b. Many of the times when I attended the sessions

   c. Some of the times when I attended the sessions

   d. At no time when I attended the sessions

8. Since participating in this project and learning to use the relaxing technique, my level of activity has increased in the following area(s)

   a. Walking longer distances

   b. Carrying on activities of daily living for longer periods

   c. Falling asleep faster and with better ease

   d. Sleeping soundly for longer periods of time

   e. All of the above

   f. None of the above. If this answer is yes, please state what activities _____.

9. In retrospect, I think that this project has been very useful to me in the following way(s)

   a. I have been able to recognize the experience of tension in my body

   b. I have been able to recognize the experience of relaxation in my body

   c. I have been successful to some extent in lowering my own body tension levels by using the relaxation technique I learned from the project

   d. I have learned to recognize the experiences of both tension and relaxation, but have never been able to lower my body tension

levels at any time and to any extent

e. None of the above

f. If the answer is any of the above, please state circumstance.

_____.

General Remarks _____

_____

_____

_____

_____

ANALYSIS OF QUESTIONNAIRE

	SUBJECTS					
	1	2	3	4	5	6
1. Factors that contribute to the precipitation of asthma attacks.						
a. Pollens	-	x	x	x	x	
b. Cold air	-	x	x			
c. Heavy smog	-		x	x	x	x
d. Exercise	-		x		x	
e. Emotional factors	-		x			x
2. Symptoms that are experienced more frequently before a full blown asthmatic attack.						
a. Coughing	x	x	x	x	x	x
b. Wheezing		x	x	x	x	
c. Tight feeling in chest	x	x	x	x	x	x
3. Since joining the asthma project has been able to relax						
a. Frequently						x
b. Occasionally	x	x		x	x	
c. Seldom		x				
d. Never			x			

ANALYSIS OF QUESTIONNAIRE

	SUBJECTS					
	1	2	3	4	5	6
4. The symptom(s) experienced less frequently or in lesser amounts and intensity due to my learned ability to relax is (are)						
a. Coughing				x	x	
b. Wheezing						x
c. Tight feeling in my chest	x	x	x	x	x	x
d. All of the above						
e. None of the above						
f. If the answer is a, b, or c, please state the circumstance(s).						
5. The complete set of exercises designed to teach me relaxation was practiced						
a. Twice each day as suggested	x			x	x	x
b. Once each day in the morning		x				
c. Once each day in the evening						
d. Not practiced as frequently as above			x			

ANALYSIS OF QUESTIONNAIRE

	SUBJECTS					
	1	2	3	4	5	6
6. Parts of the exercises were practiced during various times of the day as the need was felt to learn to relax						
a. Some part of every day	x					x
b. Not every day, but sometimes		x	x	x	x	
c. Never						
7. The biofeedback unit was beneficial in helping to recognize my tension levels during regular laboratory sessions						
a. At all times when sessions were attended	x			x	x	x
b. Many of the times when I attended the session			x			
c. Some of the times when I attended the sessions		x				
8. Since participating in this project and learning to use the relaxing technique, my level of activity has increased in the following area(s).						
a. Walking longer distances	x			no change noted		

ANALYSIS OF QUESTIONNAIRE

	SUBJECTS					
	1	2	3	4	5	6
8. b. Carrying on activities of daily living for longer periods	x	x			x	x
c. Falling asleep faster and with better ease	x		x		x	x
9. In retrospect, I think that this project has been very useful to me in the following way(s)						
a. I have been able to recognize the experience of tension in my body	x			x		x
b. I have been able to recognize the experience of relaxation in my body		x	x		x	x
c. I have been successful to some extent in lowering my own body tension levels by using the relaxation technique I learned from the project	x					x
d. I have learned to recognize the experiences of both tension and relaxation, but have never been able to lower my body tension levels at any time and to any extent	x					
e. None of the above						

x = Answer in the affirmative - = No answer given

APPENDIX D

APPENDIX D

CONSENT FORM

I have had explained to my satisfaction the procedures to be followed as a part of my participation in this project which is designed to measure physiological responses of the lungs to relaxation. I understand that as a participant, I will be asked to wear my most comfortable street clothes, and I will be taught certain relaxation exercises which I will practice at home at my convenience to enable me to relax.

The measurements to be taken will consist of placing surface electrodes on my forehead to measure my forehead muscle activity. Also during the project I will have certain pulmonary function tests done before and after the relaxation training. These will consist of my breathing into a machine which will give the following measurements of my lung function: (1) airway resistance, (2) closing volume, and (3) expiratory flow rates and volumes.

I understand that I will remain anonymous in any reports that will be made of this study, and that there will be no cost to me for the above specified pulmonary function tests done, or for the relaxation training described.

I also understand that there are certain benefits which may be reasonably expected by me as a result of my participation in the study as follows:

a. Results of tests will be available to me if I want them.

b. Benefits which may accrue to me with increased ability to relax.

I have been given an opportunity to ask questions regarding the study and the contemplated procedures, and I have received satisfactory answers to all such questions. It has also been explained to me that I may withdraw my consent at any time and discontinue my participation in this study without any prejudice to me or to the treatment of my case.

In consideration of the above, I do hereby give my free and voluntary consent to participate in the study and in the procedures which have been described above, under the direct supervision of Daphne Shah, R.N., of the Loma Linda University Graduate Program in Nursing, and the general supervision of Dorothy Martin, R.N., Ph.D., of the Loma Linda University Graduate School, and John E. Hodgkin, M.D., of the Loma Linda University School of Medicine, Section of Medical Chest Diseases.

In witness thereof I have signed this consent at Loma Linda, California, on _____, 1974.

Signature:_____

Address:_____

_____

Witness:_____

APPENDIX E

APPENDIX E

PROTOCOL FOR STUDY

I. The selection of the client.

A. The client will be selected by the physician and will meet the prescribed criteria for the sample to be used in the study. (See proposal and research design.)

II. Introduction of the study to the client.

A. The physician very briefly introduces the study to the client.

1. Pre and post testing.
2. Relaxation exercises and training.
3. Measurement of muscle tension.
4. Biofeedback.
5. States benefits client may derive from the study.
6. Introduces the therapist to the client.

III. Set appointment with client for the presession and for the initial testing of the parameters.

A. The pretesting to be done before the presession or any instructions are given to the client.

B. The presession is for the purpose of further acquainting the client with the procedures for the study.

IV. Indicate the amount of time required for participation in the study.

A. The presession and each relaxation training session will require forty-five minutes.

B. Each pulmonary function session will require about one to one-and-a-half hours.

C. Each participant will need to return to the laboratory for bio-feedback relaxation training sessions twice each week.

D. The length of the study will be four weeks and will consist of eight relaxation training sessions.

V. Obtain client's consent.

A. Read through consent form with client.

B. Explain and answer any questions that may arise.

C. Obtain signature.

There will be two short term testings done at the time of the last two relaxation training sessions in the laboratory. The pulmonary function testing will be done before and after each of these two sessions.

Pre Session Protocol

I. A short introduction to the study.

A. This will be given to verify the client's understanding of the procedures to be followed, and the relationship between tension and relaxation to the asthmatic condition.

II. Bronchoconstriction and relaxation.

A. Relate bronchoconstriction to the general tension levels of the body.

III. Explain tension as it exists in the body.

A. Tension as a function of normal daily living. (Have client tense fist as if grasping something, then make him feel aware of this tension or tenseness. Then have him relax his fist, and become aware of the difference.)

B. Tension that is or can be harmful to the body. If for any

reason the tension level in the body rises, and is maintained above that which is necessary to maintain body functions, then this increased tension level becomes harmful to the individual.

IV. Explain the effects of high tension levels in people with asthma.

A. As the entire body becomes tensed in an effort to breathe.

B. The already constricted bronchioles become more constricted and breathing becomes increasingly difficult.

V. Relaxation and Tension.

A. State that it is more desirable to be able to relax and therefore lessen the tension level, or to prevent the bronchioles from becoming constricted in the first place.

B. Demonstrate the difference between tension and relaxation.

1. Have client recall how he felt when he made the fist. Now have him make both hands into fists, and stretch both arms out in front of him while taking in a deep breath. Then instruct him to let it all out and relax, letting his arms hang loose.

VI. Introduces client to the electromyograph and feedback devices.

A. Explain that the machine is to aid in recognizing the level of muscle tension that is existing in the body at the time.

B. Demonstrate the machine and take a baseline reading.

1. Position client in chair.

2. Place electrodes on forehead and explain their function.

3. Take baseline reading from the integrator.

C. Demonstrate the feedback devices.

1. Use the visual feedback, by having the client look at and

observe the meter deflection, and explain to him its relationship to the electrical activity in his muscles at that time.

2. Use the audio feedback. Position the knob so that the tone would be at a level most acceptable to the client. Emphasize the importance of the tone, and the relationship to the tension level in the body at that time.

3. Instruct client that both audial and visual devices can be used at the same time or at any time he chooses.

VII. Discuss the experience of relaxation.

A. Impress the client with the desirability of relaxation, and the importance of being able to relax and so, if at all possible, avert a full-blown asthmatic attack.

B. Learning to relax.

1. To learn to relax is to learn to pass from the state of tenseness or tension to a state of the calmness of relaxation.

VIII. Introduce the relaxation exercises.

A. Inform the client that to be able to relax takes practice and that the exercises are designed to aid him in learning the technique of relaxing.

B. State that the exercises will help to relax beyond the normal point of the relaxation that he felt after he had made the fist previously.

C. Also the exercises will enable him to consciously and purposefully relax when he has the feeling of an asthmatic attack

coming on, as he learns to switch on that calming effect which will also hopefully relax the bronchioles as the total body relaxes.

D. Demonstrate the exercises with the client and have him repeat the demonstration.

E. Instruct client to practice exercises at least three times each day at his own convenience.

IX. Make appointments for the regular laboratory sessions.

A. Each regular session to last one hour.

B. There will be two sessions each week.

C. The study will last for four weeks, making a total of eight sessions.

D. Request client to wear comfortable clothes for laboratory sessions.

X. Close pre session.

Relaxation Training Session Protocol

I. Each session will last five minutes.

II. Client will be greeted by therapist and seated.

A. Before session begins, there will be an opportunity offered the client to go to the rest room, or to secure a drink.

III. Client will be seated in a reclining chair and electrodes will be placed on his forehead.

IV. The session begins.

A. Actual session on electromyograph with feedback lasts twenty-four minutes.

B. A B.F.T. integrator will be used with the E.M.G. biofeedback unit.

C. Readings will be recorded of the integrated tension level every two minutes for six minutes.

D. There will be four of these six minutes readings recorded each session for the purpose of data collection.

V. Session ends.

A. Client is excused and is reminded of next appointment.

VI. Those two sessions, when short term testing will be done, the client will report to the pulmonary laboratory before beginning the session proper, and again after the session is ended.

APPENDIX F

APPENDIX F

RELAXATION EXERCISES

1. Begin by sitting or lying in a comfortable position.
2. Close your eyes.
3. Make a fist with both hands.
4. Take a deep breath and stretch while tightening your arms and shoulder muscles.
5. As soon as you feel the tensing of your muscles, terminate the stretch by breathing out and letting go, thus snapping loose the tension, and relaxing.
6. Position your jaws and teeth as though you are ready to bite something that is already between your teeth.
7. Take a deep breath while biting down, and when you feel the tension in the muscles of your face and jaws, then breathe out and let it all go, while you relax.
8. Tighten your neck and stomach muscles while taking a deep breath.
9. As soon as you feel the tension in these muscles, breathe out and let the muscles hang limp, and relax.
10. Pull your toes towards your head by flexing your feet, and tighten your leg and calf muscles while taking in a deep breath.
11. As soon as you feel the tension in these muscles, breathe out and relax, allowing these muscles to hang limp.
12. Tighten every muscle in your body until you feel your muscles tingle with the tenseness or tension, while taking in a deep breath.

13. Hold the tension for a while (as long as you can tolerate it), and then breathe out, letting go completely, and relax.
14. With your eyes still closed, slowly say to yourself, "I feel very quiet and I am beginning to feel quite relaxed."
15. Beginning from your feet and moving towards your head, repeat to yourself that you feel relaxed in each body part. (Example: You will say, "My feet feel relaxed, my legs feel relaxed, my thighs feel relaxed, etc.")
16. Now relate to yourself what the sensation of relaxation is like in your experience, or how you feel when you are relaxed. (Example: "I feel light," or "I feel warm," or however the relaxation makes you feel.)
17. Repeat to yourself that this feeling (related in #16) is in each body part, beginning with your head and face. (Example: "My face and head feel light, my arms feel light," and then end by saying, "my entire body feels light."
18. Deep within your mind try to visualize and experience yourself as being comfortable and relaxed.
19. You should now be relaxed and comfortable. Remain in this relaxed condition and rest for at least fifteen minutes before getting up.
20. When the exercise and resting period are over and you are ready to get up, take a deep breath and say to yourself, "I feel relaxed and wide awake," then slowly rise to a sitting position (if you have been lying down), and slowly rise to a standing position. You should avoid getting up suddenly, or with sharp, quick motions.

Note: You are now developing the ability to relax. Practice these exercises at least twice each day, once in the morning before getting up, and

again at night before going to sleep. You may also practice parts of these exercises at any time that is available to you, while sitting or standing.

APPENDIX G

APPENDIX G

Means of Pre and Post Pulmonary Function Testing for Six

Asthmatic Subjects for Interim Testing Session I

Subject No.	CC/TLC		CV/VC		FEV_{1*}/VC		FEV_{3*}/VC		FRC		FVC		MMF		RV/TLC		TLC	
	Session		Session		Session		Session		Session		Session		Session		Session		Session	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	1.16	1.22	1.04	1.47	.85	.85	.88	.88	1.11	1.02	1.30	1.04	.53	.44	.93	.82	1.15	1.06
2	.92	.93	.75	.95	.79	.77	.82	.81	.85	.85	1.27	1.23	.33	.30	.84	.77	.94	.95
3	1.80	2.21	1.34	.78	.89	.93	.98	.99	.92	.93	1.04	.36	.38	.45	1.04	1.42	.74	.85
4					Subject was unable to complete the session													
5	.99	1.88	1.60	1.44	.75	.75	.82	.85	.93	1.08	1.52	1.36	.36	.38	.46	.74	1.17	1.26
6	1.60	1.88	1.24	2.90	.55	.51	.71	.69	1.08	1.08	.70	.62	.10	.10	1.39	1.29	.91	.90
Mean	1.25	1.47	1.19	1.46	.76	.76	.84	.84	1.18	.93	1.14	1.06	.33	.29	.93	1.00	.98	1.00

* Should read as ratio to observed vital cal capacity

APPENDIX G

Means of Pre and Post Pulmonary Function Testing for Six

Asthmatic Subjects for Interim Testing Session II

Subject No.	CC/TLC		CV/VC		FEV_1/VC		FEV_3/VC		FRC		FVC		MMF		RV/TLC		TLC	
	Session		Session		Session		Session		Session		Session		Session		Session		Session	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	1.09	1.22	1.12	1.46	.96	.81	.95	.83	1.18	1.18	1.15	1.22	.74	.38	.78	.81	1.18	1.20
2	.85	.90	.55	.79	.65	.64	.76	.37	.85	.85	1.08	1.10	.24	.10	.83	.80	.92	.97
3	2.15	2.30	3.65	4.15	1.01	.97	1.02	.99	.92	.92	1.0	1.07	.57	.53	.92	.92	.83	.82
4					Subject was unable to complete the Session													
5	1.02	1.24	1.27	1.88	.87	.77	.93	.87	1.08	1.08	1.54	1.44	.65	.46	.65	.70	1.26	1.29
6	1.92	1.85	2.78	2.83	.45	.59	.61	.76	1.12	1.08	.77	.56	.10	.10	1.40	1.26	.96	.94
Mean	1.41	1.50	1.87	2.22	.61	.76	.85	.76	1.03	1.02	1.12	1.08	.46	.31	.92	.90	1.03	1.04

APPENDIX G

Means of Pre and Post Study Pulmonary Function

Testing Results for Six Asthmatic Subjects

Subject No.	CC/TLC		CC/VC		FEV_1/VC		FEV_3/VC		FRC		FVC		MMF		RV/TLC		TLC	
	Study		Study		Study		Study		Study		Study		Study		Study		Study	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	1.52	1.22	1.80	1.46	.59	.81	.73	.83	1.18	1.18	.96	1.22	.15	1.20	1.14	.81	1.15	1.20
2	1.12	.90	1.08	.79	.66	.64	.78	.37	.85	.85	.92	1.10	.19	.10	1.02	.80	1.06	.97
3	2.12	2.30	3.41	4.15	1.03	.97	1.02	.99	.92	.92	1.15	1.07	.62	.53	.94	.95	1.11	.82
4	1.30	1.41	.59	1.30	.60	.72	.68	.83	1.32	1.32	1.0	.81	.43	.21	1.29	1.31	1.23	1.14
5	.97	.92	.98	1.08	.77	.71	.89	.82	.93	1.08	1.28	1.39	.45	.35	.72	.61	1.25	1.23
6	1.85	1.85	1.0	2.83	.57	.59	.76	.76	1.08	1.08	.46	.56	.38	.10	1.14	1.26	.92	.94
Mean	1.48	1.43	1.44	1.43	.70	.79	.81	.76	1.04	1.07	.96	1.02	.37	.39	1.04	.95	1.12	1.05

APPENDIX H

APPENDIX H

TWO-WAY ANALYSIS OF VARIANCE TABLE OF CLOSING CAPACITY/CLOSING VOLUMES FOR THE FIVE SUBJECTS COMPLETING THE TWO INTERIM TESTING.

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARES	P. VALUE	SIGNIFICANCE
ROW	.095253	1	.095253	.02	SIGNIFICANT
COLUMN	4.29747	4	1.07437	.01	SIGNIFICANT
INTERACTION	3.64914E-2	4	9.12285E-3	.06	NOT SIGNIFICANT

COLUMN - SUBJECT

ROW - SESSION