CHANGES IN PULMONARY EFFICIENCY AND WORKING CAPACITY OF ASTHMATIC AND NON-ASTHMATIC CHILDREN IN A SWIMMING PROGRAM

A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ARTS IN PHYSICAL EDUCATION IN THE GRADUATE SCHOOL OF THE TEXAS WOMAN'S UNIVERSITY

COLLEGE OF
HEALTH, PHYSICAL EDUCATION, AND RECREATION

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DENTON, TEXAS
DECEMBER, 1971

Texas Woman's University

Denton, Texas

December 14, 19 71

We hereby recommend that the thesis prepared under our supervision by Elsa Dorothea Claverie entitled Changes in Pulmonary Efficiency and Working Capacity of Asthmatic and Non-asthmatic Children in a Swimming Program

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ACKNOWLEDGMENTS

For the guidance, support, strength, and friendship of Dr. Claudine Sherrill - the writer is deeply, sincerely thankful.

For the suggestions, contributions, and generous giving of time and energy by committee members Dr. Joel Rosentswieg, Dr. Marjorie Keele, M.D., and Dr. Marilyn Hinson - the writer is deeply, sincerely thankful.

For the time and help given by the faithful assistants - the writer is deeply, sincerely thankful.

For the enthusiastic boys and girls in the program and their cooperative parents - the writer is deeply, sincerely thankful.

For the constant encouragement and tedious art work of Katherine Ricks; for the friendship and interest of Jo Littleton; for the time, skills, and companionship of Laurie Hammett, a great typist; for the love and care of family and friends; and, above all, for the love of God - the writer is deeply, sincerely thankful.

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CHAPTER I

INTRODUCTION

Orientation to the Study

Asthma accounts for approximately 25 per cent of school absenteeism in the United States.[1] The leading chronic disease in the age group below eighteen years, asthma afflicts approximately two million children.[2] The child with asthma presents a unique and difficult therapeutic challenge because many factors influence the disease. There are specific factors, such as an allergy to a particular substance, and non-specific factors, such as physical condition, breathing methods, posture, infection, fatigue, irritating substances, and emotions. The non-specific factors may either cause, irritate, or complicate the asthma, so their treatment may often be as important as the elimination of the specific allergens.[3]

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[1]Sydney E. Salmon and Robert W. Schrier, "The Newer Aspects of Asthma," California Medicine, CXIII (October, 1970), 17.

[2]Kay H. Petersen and Thomas R. McElhenney, "Effects of a Physical Fitness Program Upon Asthmatic Boys," Pediatrics, XXXV (February, 1965), 295.

[3]Tuberculosis and Health Association of Hennepin County, "Physical Conditioning Program for Asthmatic Children," Journal of School Health, XXXVII (February, 1967), 107.

Asthmatic children often succumb to a pattern of repeated suppression of physical activity that deprives them of initiative, self-reliance, and confidence. When this situation occurs, the asthmatic child refrains from participating in physical activities even when free from asthma. This may result in mental suffering as well as physical incapacity.[1]

Studies have shown that asthmatic children who participate in controlled programs of physical conditioning may be expected to show improvement in pulmonary function and cardiovascular efficiency as well as a decrease in the frequency and severity of asthmatic attacks.[2] Swimming, a healthful and enjoyable activity, improves physical condition and stresses breath control. It has been found to be highly beneficial in the treatment as asthma.[3,4,5,6] Most

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[1]Merle S. Scherr and Lawrence Frankel, "Physical Conditioning Program for Asthmatic Children," Journal of the American Medical Association, CLXVIII (December 13, 1958), 1996.

[2]Milton Millman, et al., "Controlled Exercise in Asthmatic Children," Annals of Allergy, XXIII (May, 1965), 220.

[3]Hyman Chai and Constantine J. Falliers, "Controlled Swimming in Asthmatic Children," Journal of Allergy, XLI (February, 1968), 93.

[4]Stanley L. Goldman, et al., "Children's Asthmatic Rehabilitation Program," Annals of Allergy, XXIV (July, 1966), 346.

[5]Committee on Children with Handicaps, "The Asthmatic Child and His Participation in Sports and Physical Education," Pediatrics, XLV (January, 1970), 150.

[6]Samuel J. Taub, "An Exercise Program for the Allergic Child," The Eye, Ear, Nose and Throat Monthly, XLVIII (August, 1969), 92.

of the findings with respect to improvement in physical condition, however, are subjective in nature since few research studies have yielded statistical evidence which show significant improvement in pulmonary efficiency and cardiovascular endurance.

It was anticipated that the present study would be a valuable contribution to the available literature concerning the influence of swimming upon pulmonary efficiency and working capacity and would encourage further research concerning the use of swimming as a rehabilitative measure for various diseases. It was hoped, also, to provide additional information to persons interested in conducting similar programs for asthmatic and non-asthmatic children.

Statement of the Problem

The present investigation entailed a study of twenty-eight asthmatic and twenty-eight non-asthmatic boys and girls, aged five through twelve years, who resided in Denton, Texas, during the summer of 1971, to determine the relationship between participation in a swimming program and changes in pulmonary efficiency and working capacity as revealed by values on tests for one-second forced expiratory volume, maximal breathing capacity, and submaximal working capacity. The subjects were assigned at random to four groups, each comprised of fourteen children. Two experimental groups participated five days a week for a period of four weeks in a program of swimming instructions and two control groups adhered to their routine daily living activities. Upon the basis of the findings, the investigator drew a conclusion with respect to the relationship between participation in a swimming program and changes in pulmonary efficiency and working capacity of selected asthmatic and non-asthmatic children.

Definitions and/or Explanations of Terms

For the purposes of clarification, the following definitions and/or explanations of terms were established for use in the present study:

Asthma: The American Thoracic Society defines asthma by stating that:

> Asthma is a disease characterized by an increased responsiveness of the trachea and bronchi to various stimuli and manifested by a widespread narrowing of the airways that changes in severity either spontaneously or as a result of therapy.[1]

Pulmonary Efficiency: For the purpose of the present study, pulmonary efficiency was defined as the degree of ability to move gases into and out of the lungs. Pulmonary efficiency was measured by forced expiratory volume for one second and by maximal breathing capacity.

Forced Expiratory Volume for One Second (FEV_1): The investigator accepted Kazemi's explanation of forced expiratory volume for one second. Kazemi stated:

> Timed vital capacity is the volume of air exhaled after a full inspiration per unit time and

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[1] American Thoracic Society, "Chronic Bronchitis, Asthma, and Pulmonary Emphysema," American Review of Respiratory Diseases, LXXXV (May, 1962), 763.

> it is presented as a fraction of the total vital capacity. Commonly, the forced expired volume in the first second (FEV_1) is measured.[1]

In the present study, the Collins 13.5 liter Respirometer yielded a value in cubic centimeters exhaled in one second. Throughout the study, forced expiratory volume for one second was referred to as FEV_1.

Maximal Breathing Capacity: Kazemi's definition of maximal breathing capacity was stated:

> To determine the MBC the patient is asked to breathe as hard and as fast as possible for a given period of time, usually 15 seconds, and then the volume of the expired air is collected and measured. The final value is given in liters per minute.[2]

Working Capacity: The investigator explained that working capacity is the maximum level of work that an individual is capable of producing at a steady state.[3] In the present study, working capacity was evaluated by the Submaximal Working Capacity-170 Test.[4]

Submaximal Working Capacity-170 Test (SWC_{170}): The Submaximal Working Capacity-170 Test determines the estimated

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[1]Homayoun Kazemi, "Pulmonary-Function Tests," Journal of the American Medical Association, CCVI (December, 1968), 2302.

[2]Ibid.

[3]Holger Wahlund, "Determination of the Physical Working Capacity," Acta Medica Scandinavica, suppl. 215 (1948), 7-78.

[4]Eugene V. Doroschuk, "A Short Test of Submaximal Working Capacity (SWC_{170})," Journal of the Canadian Association for Health, Physical Education, and Recreation, XXXII (December-January, 1965-1966), 10.

amount of work that corresponds to a heart rate of 170 beats per minute during exercise on the bicycle ergometer. Throughout the study, the test was referred to as SWC_{170}.

Purposes of the Study

The general purpose of the present study was to examine the hypothesis that there was no difference between the control groups and the experimental groups after the experimental period with respect to pulmonary efficiency as measured by forced expiratory volume for one second and maximal breathing capacity, and working capacity as determined by the Submaximal Working Capacity-170 Test. Specifically, the following null hypotheses were examined: There is no difference between the asthmatic control group, asthmatic experimental group, non-asthmatic control group, and non-asthmatic experimental group after the experimental period with respect to pulmonary efficiency as measured by forced expiratory volume for one second and maximal breathing capacity, and working capacity as determined by Submaximal Working Capacity-170.

Delimitations of the Study

The present study was subject to the following delimitations:

(1) Twenty-eight asthmatic and twenty-eight non-asthmatic children, aged five through twelve years, who resided in Denton, Texas, during the summer of 1971.

(2) Cooperation of the parents in providing personal data and transportation for their children during the testing periods.

(3) The extent to which the twenty-eight subjects in the two control groups adhered to their routine daily living activities.

(4) The reliability, validity, and objectivity of the selected tests for pulmonary efficiency and working capacity.

(5) The environmental conditions with respect to weather, dust, pollen, and mold.

(6) Motivational devices and instructional techniques used by the investigator and her eight teaching assistants.

(7) The extent to which the swimming program demanded optimum pulmonary effort on the part of the participants.

Summary

Asthma is the leading chronic disease of children in the United States. The asthmatic child often considers himself as handicapped and develops a pattern of inactivity. This suppression of activity deprives him of the opportunity to develop to the optimum level of physical and mental performance. Numerous programs of physical conditioning have been developed in different regions of the United States to aid in the treatment of the non-specific factors involved in asthma. Participation in these programs resulted in improved pulmonary function and cardiovascular efficiency, and a decrease in asthmatic attacks. Swimming is often a very important phase in programs of physical conditioning for the asthmatic subject.

The present investigation entailed a study of twenty-eight asthmatic and twenty-eight non-asthmatic boys and girls to determine the relationship between participation in a swimming program and changes in pulmonary efficiency and working capacity. The subjects, aged five through twelve years, were assigned at random to four groups. The two experimental groups participated in a swimming program five days a week for a period of four weeks, whereas the two control groups adhered to their routine daily living activities.

Prior to the beginning of the study and at the conclusion of the experimental period, the subjects were administered tests to determine pulmonary efficiency and working capacity. The tests selected to measure pulmonary efficiency were the forced expiratory volume for one second (FEV_1) and maximal breathing capacity (MBC). The test selected to determine working capacity was Submaximal Working Capacity-170 (SWC_{170}).

In Chapter II of this thesis, a review of related literature is presented under the following center headings: (1) History and Nature of Asthma, (2) Research Concerning One-second Forced Expiratory Volume, (3) Research Concerning

Maximal Breathing Capacity, (4) Research Concerning Submaximal Working Capacity-170, and (5) Research Studies of Physical Conditioning and/or Swimming for Asthmatic Children.

CHAPTER II

SURVEY OF RELATED LITERATURE

The general purpose of the present study was to determine changes in pulmonary efficiency and working capacity of asthmatic and non-asthmatic children in a swimming program. A comprehensive review of the related literature disclosed that numerous studies have been conducted to determine the value of swimming in the rehabilitation of asthmatic patients, but the present study did not duplicate any previous investigation. In this chapter of the thesis, related literature will be reviewed under the following center headings: History and Nature of Asthma, Research Concerning One-second Forced Expiratory Volume, Research Concerning Maximal Breathing Capacity, Research Concerning Submaximal Working Capacity-170, and Research Studies of Physical Conditioning and/or Swimming for Asthmatic Children.

History and Nature of Asthma

The word "asthma," derived from the Greek language, means "panting" or "gasping for breath."[1] Unger mentioned

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[1] Irvin Caplin, The Allergic Asthmatic (Springfield, Illinois: Charles C. Thomas, 1968), p. 5.

finding evidence of asthma described as "anguish" in the Bible.[1] The Greeks described attacks of asthma as early as 500 B.C. The ancients, exceedingly good observers, termed slight difficulty of breathing dyspnea, and laborious respiration asthma. Hippocrates (460-357 B.C.) mentioned asthma and described the spasmodic nature of the disease, comparing it to epilepsy.[2]

In the twelfth century, the symptoms of asthma were described in detail. Moses Maimonides, the great Jewish philosopher and learned physician, wrote the Tractus Contra Passionem Asthmatis, in which he described the symptoms of asthma.[3]

Following the Dark Ages, during which time no progress occurred with respect to understanding the nature, causes, and treatment of asthma, the Renaissance resulted in research in medicine as well as other fields of endeavor. Despite the advancement of knowledge and new techniques, however, asthma was still confused with tuberculosis, heart disease, and other conditions.

From 1859 to 1911, numerous advances occurred in the diagnosis, treatment, and understanding of asthma. In 1859, Henry Hyde Salter, an asthmatic, was the first man to

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[1]Leon Unger, Bronchial Asthma (Springfield, Illinois: Charles C. Thomas, 1945), p. 10.

[2]M. H. Kahn, "Historical Survey of Our Knowledge of Bronchial Asthma," Medical Life, XXXV (March, 1928), 112.

[3]Unger, Bronchial Asthma, p. 14.

perform a positive skin test. Salter believed that asthma was inherited and described the changes in the lungs of an asthmatic.[1] In 1880, Dr. Henry Sewall demonstrated the prevention and treatment of asthma with injections. By injecting snake venom into pigeons, he showed that an immunity could be developed so that subsequent snake bites were harmless.[2] From 1890 to 1910, experiments were limited to animals since severe reactions occurred after injections of antitoxins. In 1906, Dr. Clemens von Pirquet coined a new word, "allergy," which is also derived from the Greek, and means an "altered reaction."[3] In 1911, Dr. Leonard Noon and Dr. John Freeman treated several patients with injections of extracts of boiled grass pollen. This marked the beginning of the present trend in the treatment of allergies.[4]

It is estimated that about five per cent of the population of the United States has asthma. Approximately 25 per cent of school absenteeism results from asthma. Males predominate to a slight extent. Asthma occurs in all races,

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[1] Henry Hyde Salter, On Asthma: Its Pathology and Treatment (London: Churchill, 1860).

[2] Caplin, The Allergic Asthmatic, p. 8.

[3] Vincent J. Derbes and Hugo Tristram Engelhardt, The Treatment of Bronchial Asthma (Philadelphia: J. B. Lippincott Company, 1946) citing Clemens von Pirquet, "Klinische Studien ueber Vaccination and Vaccinale Allergie," Münchener Medizinische Wochenschrift, LIII (1906), 457.

[4] Caplin, The Allergic Asthmatic.

but it is rare in Eskimos and full-blooded Indians. No age is exempt, but it is more frequent in the first decade of life.[1]

Several articles have been printed concerning the advantages and disadvantages of physical activity, particularly breathing exercises, in the management of asthma. In 1970, the Committee on Children with Handicaps[2] presented a statement concerning the asthmatic child and his participation in sports and physical education that had also been reviewed and approved by the Joint Committee on Physical Fitness, Recreation, and Sports Medicine of the American Academy of Pediatrics. Asthma "probably contributes to inefficient school work because of chronic fatigue, irritability, decreased attention span, and secondary emotional disorders."[3] Most asthmatic children should, however, attend regular school. Except in certain instances, no special facilities are needed.

Members of the Committee on Children with Handicaps stated that the asthmatic child needs both physical and mental activity. The majority of asthmatic children can participate in physical activities at school with proper medical management. Efforts should be made to minimize

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[1]Unger, Bronchial Asthma, p. 44.

[2]Committee on Children with Handicaps, "The Asthmatic Child and his Participation in Sports and Physical Education," Pediatrics, XLV (January, 1970), 150-151.

[3]Ibid., p. 150.

restrictions and to invoke them only when necessary. In severe asthma cases, sports involving body contact should be prohibited. Individual sports and gymnastics should be encouraged, yet evaluated on an individual basis. Swimming can be helpful, and should be enjoyed. Periodic examinations should be conducted on each asthmatic child, and written records filed in the school office. Physicians should become familiar with the physical education and athletic programs in the schools attended by asthmatic patients. If a decision is to be made to modify participation in school athletics and physical education, the child's physician, parents, and teachers should be involved.[1]

The report concluded that, with proper balance of activities and optimal management of the disease, the asthmatic child should be able to develop the self-confidence necessary to grow and mature in a satisfactory manner.[2]

Itkin[3] reported on the advantages and disadvantages of exercise as compared with bed rest, limited activity, conditioning exercises, and breathing exercises in asthmatic persons. While bed rest would appear to be the safest form of treatment for the asthmatic patient during and between attacks, it encourages the development of pneumonia, atrophy of muscles, retardation of growth, and airway obstruction.

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[1]*Ibid*., p. 151 [2]*Ibid*., p. 151.

[3]Irving H. Itkin, "The Pro's and Con's of Exercise for the Person with Asthma," *American Journal of Nursing*, LXVI (July, 1966), 1584-1587.

The patient may also become more susceptible to infection and, psychologically, become self-destructive.

In limited activities, asthma becomes more severe, and airway obstruction and the ability to perform do not exhibit any changes. Psychologically, the development of social relationships may be limited, schooling may be disrupted, and motivation may be weakened. Limited activity usually deprives the child of the fullest enjoyment derived from participation in sports and other physical activities.[1]

Itkin cites a study of conditioning exercises as compared with the effects of limited activity upon asthmatic patients. A detailed discussion of the conclusions of Itkin's study is found on page 43 of the thesis.

Itkin states that breathing exercises have been recommended to the asthmatic patient because they strengthen respiratory muscles, provide better ventilation, and bring about a more efficient breathing pattern. While the effect of breathing exercises on complications has not been studied thoroughly, it would be worthwhile to know whether the exercises may prevent chest deformities in children. The psychologic effect of breathing exercises is thought to be generally good.[2]

Itkin recommended that exercise should not be used for patients if it consistently precipitates attacks. Exercise is, however, useful between attacks for the majority

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[1] Ibid., p. 1585.

[2] Ibid.

of asthmatic persons because it is rehabilitative physically as well as psychologically. Itkin concluded that the asthmatic person should be given the same opportunity as the healthy individual to benefit from physical exercise.

As early as 1935, Livingstone and Gillespie[1] investigated the value of breathing exercises in the asthma clinic at King's College Hospital in England. The subjects utilized in the study were seventy-five male and female patients, aged three to seventy-five years, who were observed for a minimum of twelve months and a maximum of two years. A control group comprised of fifty patients received selected treatment, but did not practice breathing exercises.

The aim of the breathing exercises was the education of the patients in the proper control of the diaphragm and the mobilization of the chest wall. The exercises, as presented by the Asthma Research Council, were simple and well-recognized. The authors taught the subjects in the experimental group to take a short inspiration through the nose and then make a long expiration through the mouth, with a whistling or hissing noise. The exercises were practiced two or three times a day for at least ten minutes. The subjects were encouraged to practice the exercises gently when they felt an imminent attack in an attempt to abort it.

A complete history was taken of each subject. Clinical examinations were performed, including measurements

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[1]James L. Livingstone and Marjorie Gillespie, "The Value of Breathing Exercises in Asthma, Lancet, II (September 28, 1935), 705-708.

of chest expansion every three months and screening of the diaphragmatic movements before and after the experimental period. The experimental group revealed distinct clinical improvement in fifty-two of the seventy-five cases, improvement in twelve cases, and no improvement in eleven subjects who were unable to learn diaphragmatic control. In the control group, thirty-six subjects showed clinical improvement. Diaphragmatic movements showed good excursion in fifty-four of the subjects in the experimental group. The actual measurements of chest expansion varied with the age and sex of the individual, but there was an average increase of two and one-half inches in the subjects practicing diaphragmatic breathing. One-half of the patients in the experimental group stated that they could abort all but very severe attacks by doing breathing exercises.

In comparing the control group, which was prescribed certain drugs and forbidden any other treatment, with the experimental group, the proportion of good results appeared to be almost identical. The authors stressed the value of breathing exercises as a practical form of therapy, "since equally good results were obtained with this simple treatment as with the more complicated and specific measures practised in the control group."[1] It was concluded, however, that specific treatment should not be neglected for breathing exercises alone.

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[1]Ibid., p. 708.

Livingstone[1] reported on the results of breathing exercises of his patients over a period of twenty years. Of the seventy-five per cent who really tried to learn the exercises, sixty per cent acquired controlled breathing. He estimated that ten per cent of those who acquired breathing control failed to improve materially.

Following the acquisition of breath control, Livingstone stated, it is important that the asthmatic individual engage in graduated athletic exercise. Many physicians, however, "forbid games or any running at all."[2] Livingstone noted that more harm is done by forbidding games, and the patients are denied physical fitness. Many patients who have reached "the maximum of 'training' for their capabilities"[3] report that bronchospasm has diminished or ceased.

Livingstone suggested that children be encouraged to participate in games at school. In the older age-groups, many patients can be graded up to swim and play tennis by skipping and running. For the middle-aged and elderly patients, walking may be gradually increased until the individual reaches the "best time within his capacity."[4] It

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[1]James L. Livingstone, "Physical Treatment in Asthma," The British Journal of Physical Medicine, XV (June, 1952), 136-139.

[2]Ibid., p. 138.

[3]Ibid., p. 137.

[4]Ibid., p. 138.

was concluded that an asthmatic patient is not given the maximum benefit if physical treatment is omitted.

Fein and Cox[1] reported on the exact routine and techniques of respiratory and physical exercises as outlined by the Asthma Research Council of London, England.[2] The necessary personnel and equipment were described, and the method of employing respiratory and physical exercise in the treatment of bronchial asthma was presented. Twelve elementary exercises and the specific methods of instruction were described, accompanied by photographs of each exercise.

Measurements were obtained to determine the results of the exercises. An expansometer measured the chest, and a caliper measured the movement of the upper segments of the chest. A vital capacity apparatus was used to record lung capacity.

It was suggested that the exercises be performed in conjunction with regular allergic and medical therapies. Mechanical devices should be utilized to the fullest benefit. The authors, who have used the exercises with private patients, state that they have obtained gratifying results.

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[1]Bernard T. Fein and Eugenia P. Cox, "The Technique of Respiratory and Physical Exercise in the Treatment of Bronchial Asthma," Annals of Allergy, XII (July-August, 1955), 377-384.

[2]Asthma Research Council, Physical Exercises for Asthma (London: Headley Brothers, 1934).

May[1] reported on the breathing exercises used in 1952 at the Brompton Hospital for Diseases of the Chest in London, where physical therapy was considered an integral and essential part of the patient's treatment and rehabilitation. An examination by the physical therapist before treatment included a careful assessment and record of posture including shape and movement of the chest. Chest measurements, taken three times with a tape measure, were recorded at rest, on inspiration, and on expiration. The vital capacity was taken before treatment and again at monthly intervals. It was reported that asthmatic patients tended to have a lower vital capacity than normal.

The aims of physical treatment were to achieve relaxation, retrain breathing habits and teach breath control, and to develop good posture at all times. Rhythmic swinging exercises and stretching-relaxing exercises were performed to teach relaxation. The breathing exercises were those recommended by the Asthma Research Council of London.[2] A description of each exercise was included. Classes were conducted for forty-five minutes twice a week to check breathing exercises, practice relaxation, and develop good posture. The importance of constant practice was stressed, and the patients were encouraged to become self-reliant.

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[1]Evelyn A. May, "Physical Therapy in Medical Diseases of the Chest," The Physical Therapy Review, XXXII (March, 1952), 121-126.

[2]Asthma Research Council, Physical Exercises for Asthma (London: Headley Brothers, 1934).

The diagnosis of asthma involves the use of certain nonclinical objective tests. The best test to diagnose asthma, or to determine if the condition is improving, utilizes a spirometer, which has the advantage of providing a written record of the subjects' efforts.[1] Numerous investigators[2-10] have employed the FEV_1 test to measure pulmonary

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[1]Samuel C. Bukantz, "Objective Tests for Bronchial Asthma," Journal of the American Medical Association, CCXI (March 9, 1970), 1707.

[2]Millman, "Controlled Exercise," 220-225.

[3]I. Leonard Bernstein, et al., "Pulmonary Function in Children," Journal of Allergy, XXX (November-December, 1959), 514-533.

[4]Pierre H. Beaudry, Melvin B. Wise, and Janet E. Seely, "Respiratory Gas Exchange at Rest and During Exercise in Normal and Asthmatic Children," American Review of Respiratory Disease, XCV (February, 1967), 248-253.

[5]Michael Hirt, "Physical Conditioning in Asthma I," Annals of Allergy, XXII (May, 1964), 229-237.

[6]John S. Hyde and Charles L. Swarts, "Effect of an Exercise Program on the Perenially Asthmatic Child," American Journal of Diseases of Children, CXVI (October, 1968), 383-396.

[7]L. H. Capel and J. Smart, "The Forced Expiratory Volume after Exercise, Forced Inspiration, and the Valsalva and Müller Manoevres," Thorax, XIV (June, 1959), 161-165.

[8]Irving H. Itkin and Martin Nacman, "The Effect of Exercise on the Hospitalized Asthmatic Patient," The Journal of Allergy, XXXVII (May, 1966), 253-263.

[9]Trude Seligman, H. O. Randel, and J. J. Stevens, "Conditioning Program for Children with Asthma," Physical Therapy, L (May, 1970), 641-647.

[10]Hyman Chai and Constantine J. Falliers, "Controlled Swimming in Asthmatic Children: An Evaluation of Physiological and Subjective Data," Journal of Allergy, XLI (February, 1968), 93.

efficiency of asthmatic and non-asthmatic children. The asthmatic subject characteristically shows a lower FEV_1 value than the non-asthmatic. In the section which follows, studies based upon measures of FEV_1 in both normal and asthmatic children are reviewed.

Research Concerning One-second Forced Expiratory Volume

Strang[1] tested 209 boys and 209 girls to establish standards for normal children between seven and eighteen years of age in terms of forced expiratory volume in one second (FEV_1). The subjects attended three different schools located in a residential area of Newcastle upon Tyne. A random sample of twenty boys and twenty girls in each age group was taken from the available schools.

Readings were made with a spirometer. Each child was instructed to take in a deep breath and breathe out as fast and far as possible into the plastic tube. From the five recordings, the mean value of the best three was calculated for the FEV_1. The height and weight of each child were measured and recorded.

The results showed consistence between different readings in individual children. Ninety-five per cent of the readings were within 3.8 per cent of the individual mean values. Coefficients of correlation were calculated for FEV_1 with age, weight, body surface area, height, and height

[1] Leonard B. Strang, "The Ventilatory Capacity of Normal Children," Thorax, XIV (December, 1959), 305-310.

cubed. Height and the cube of the height in boys (r = .92) and girls (r = .93) were slightly better correlated with FEV_1 than the other parameters which were compared. Age and FEV_1 had a correlation coefficient of .88 for boys, and .89 for girls. Weight and FEV_1 had a correlation coefficient of .80 for boys and .72 for girls. When weight was taken into account, there was little difference between the FEV_1 values for boys and girls.

The results of the study were presented in tabular form which allowed for the prediction of normal ventilatory capacity in terms of the FEV_1 from a child's height or from his age. It was recommended that the height rather than age be used to obtain the expected value for FEV_1, since children of the same age differ considerably in height.

Bernstein _et al_.[1] conducted a study to derive prediction equations for vital capacity, timed vital capacity (FEV), maximum breathing capacity, functional residual capacity, and total lung capacity in children. The subjects who participated in the study were seventy normal, healthy boys and girls ranging in age from six through fifteen years.

The prediction indices chosen for use in the study were the age, height, and weight of the child. The height and weight of the subjects used in the study correlated with

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[1] Bernstein, _et al_., "Pulmonary Function in Children," 514-533.

standard anthropometric tables for children in their respective age groups.

A 9 liter Collins spirometer was used to collect measurements of lung volumes including timed and vital capacities, expiratory reserve volume, and inspiratory capacity. The maximum breathing capacities for a twelve-second interval were determined also. The lung volumes were calculated, and simple scattergraphs were constructed with age, weight, height, and body surface area factors along the abscissae and the observed pulmonary function data along the ordinates. The results revealed that the pulmonary data and physical characteristics were highly intercorrelated, and the relationship was essentially linear.

It was concluded that the sample used for the study was representative of the population studied by other investigators and, by inference, of the population of normal children. A comparison of the resulting predicted normal values with previous similar investigators such as Stewart, Robinson, and Ferris and Smith revealed general agreement.

Beaudry, Wise, and Seely[1] compared twelve asthmatic children with a mean age of 11.90 years, and eighteen normal children with a mean age of 11.55 years with respect to ventilatory capacity before and after exercise; total

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[1]Pierre H. Beaudry, Melvin B. Wise, and Janet E. Seely, "Respiratory Gas Exchange at Rest and During Exercise in Normal and Asthmatic Children," American Review of Respiratory Disease, XCV (February, 1967), 248-254.

ventilation, oxygen and carbon dioxide exchange during exercise, and additional aspects of gas exchange at reat and after exercise. The $FEV_{0.75}$ of each subject was measured before and after the seven- to ten-minute period of steady exercise on the bicycle ergometer. A work load on the ergometer was set so that the oxygen uptake during exercise was approximately three times that at rest. The expired gas of each subject was collected for two to three minutes following a period of exercise, and blood was taken from the fingertip. The oxygen and carbon dioxide in the expired gases were measured to determine the exchange during exercise, and the blood samples were analyzed to measure the acid base during exercise. The physiologic dead space[1] was calculated also, to determine changes of ventilation.

The data collected revealed that the mean $FEV_{0.75}$ of the asthmatic group correlated with the severity of the disease and was significantly lower than that of the normal group. The mean $FEV_{0.75}$ of the asthmatic group did not change significantly after the period of exercise, although there were considerable individual variations. The physiologic dead space was significantly greater in the asthmatic group than in the normal group, but did not increase or

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[1]Edward A. Gaensler and George W. Wright, "Evaluation of Respiratory Impairment," Archives of Environmental Health, XII (February, 1966), 165. "Ventilation of alveoli which are not perfused with blood or, more commonly, underperfused with respect to their ventilation, creates additional dead space which, added to the anatomic dead space, is called the physiologic dead space."

decrease in either group as a result of the exercise. The minute ventilation showed more increase as the result of exercise in the asthmatic children than in the normal group. The mean oxygen uptake and carbon dioxide output both at rest and during exercise appeared to be almost identical in the normal group and in the asthmatic group.

Capel and Smart[1] conducted an investigation to study the effect of exercise on one-second forced expiratory volume (FEV_1). The subjects were forty-eight patients of the London Chest Hospital, thirty with obstructive airway disease, fifteen with mild heart disease or lung disease without airway obstruction, and six healthy persons.

The FEV_1 of each subject was measured at rest, immediately following the performance of a step test, and after five minutes' recovery. The results revealed an increase in the FEV_1 immediately following exercise only in patients with obstructive airway disease. The mean increase was twenty-four per cent of the resting value. After five minutes' recovery, the FEV_1 for the patients with obstructive airway diseases returned to a mean three per cent above the resting value. The healthy subjects and patients with heart disease or lung disease showed no increase in FEV_1 after exercise. It was believed that more strenuous exercise might have increased the FEV_1 in healthy subjects.

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[1]L. H. Capel and J. Smart, "The Forced Expiratory Volume after Exercise, Forced Inspiration, and the Valsalva and Müller Manoeuvres," Thorax, XIV (June, 1959), 161-165.

Capel and Smart suggested that the rise in FEV_1 which followed exercise might be the result of a fall in airway resistance in the patients with obstructive airway disease.

A second study was conducted by Capel and Smart[1] to determine the effect of variations in the speed of inspiration on the FEV_1. The subjects were thirty-one patients with obstructive airway disease and six healthy individuals. The FEV_1 of each subject was recorded after a slow inspiration and after a forced inspiration from a full expiration. The order of the recordings was varied. The results showed that the FEV_1 of patients with obstructive airway disease exhibited an increase in the mean value after the forced inspiration ten per cent above the FEV_1 measured after a slow inspiration. The normal subjects and patients with heart disease showed little change. It was concluded that an increase in the FEV_1 followed a forced inspiration.

Several investigators have studied the effects of participation in physical education activities upon changes in FEV_1 of asthmatic children. Seligman, Randel, and Stevens;[2] Chai and Falliers;[3] Chai *et al.*;[4] Hyde and Swarts;[5]

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[1] *Ibid.*

[2] Seligman, Randel, and Stevens, "Conditioning Program for Children with Asthma," 641-647.

[3] Chai and Falliers, "Controlled Swimming in Asthmatic Children," 93.

[4] Hyman Chai, *et al.*, "Long-term Investigation into the Effects of Physical Therapy in Chronically Asthmatic Children," *Journal of Allergy*, XXXIX (February, 1967), 109.

[5] Hyde and Swarts, "Effect of an Exercise Program on the Perennially Asthmatic Child," 383-396.

Hirt;[1] Millman et al.;[2] and Franklin[3] all found no significant differences in FEV_1 between pretest and posttest values. Itkin and Nacman,[4] however, found some significant differences in FEV_1 values. The specific research designs of these studies are described fully on pages 35 through 42.

Research Concerning Maximal Breathing Capacity

In addition to the FEV_1 test, several investigators[5-10] have utilized the MBC test to measure pulmonary efficiency

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[1]Hirt, "Physical Conditioning in Asthma I," 229-237.

[2]Millman, et al., "Controlled Exercise," 220-225.

[3]Janice Carrie Franklin, "An Experimental Study of Physical Conditioning for Asthmatic Children" (unpublished Master's thesis, Texas Woman's University, 1971).

[4]Itkin and Nacman, "The Effect of Exercise on the Hospitalized Asthmatic Patient," 253-263.

[5]B. G. Ferris, J. L. Whittenberger, and J. R. Gallagher, "Maximum Breathing Capacity and Vital Capacity of Male Children and Adolescents," Pediatrics, IX (June, 1952), 659-669.

[6]B. G. Ferris and C. W. Smith, "Maximum Breathing Capacity and Vital Capacity in Female Children and Adolescents," Pediatrics, XII (October, 1953), 341-351.

[7]Franklin, "An Experimental Study of Physical Conditioning for Asthmatic Children."

[8]Bernstein, et al., "Pulmonary Function in Children."

[9]Hyde and Swarts, "Effect of an Exercise Program on the Perennially Asthmatic Child," 383-396.

[10]Millman, et al., "Controlled Exercise," 220-225.

in asthmatic and non-asthmatic children. The MBC, a measurement to assess the ability of the lungs to work,[1] has been found to correlate more closely with subjective dyspnea than does any other test.[2]

Numerous studies have been conducted to establish norms for the Maximal Breathing Capacity of adults, but few have attempted to formulate norms for children. Ferris, Whittenberger, and Gallagher[3] studied 161 boys aged five to eighteen years in an effort to develop norms. Vital capacities and MBC were measured by means of a Benedict-Roth type spirometer. The largest of three maximum expirations following a maximum inspiration was recorded as the vital capacity. If a progressive rise in values was obtained, further determinations were made. The training factor is influential in MBC, so more than three trials were often necessary. The largest of the three or more trials of MBC was recorded. The age, height, weight, and body surface area of each subject were recorded also.

The average vital capacities and maximal breathing capacities for the various groupings were presented in tabular form. The individual vital capacities and maximal breathing capacities were plotted as scattergrams against

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[1] Ibid., p. 222.

[2] Gaensler and Wright, "Evaluation of Respiratory Impairment," 146-189.

[3] Ferris, Whittenberger, and Gallagher, "Maximum Breathing Capacity and Vital Capacity of Male Children and Adolescents," 659-669.

the ages, heights, weights, and body surface areas. It was noted that a change of slope occurred in the maximal breathing capacities and vital capacities when they were plotted against age. The age at which this change of slope occurred, from twelve to fourteen years, is a period characterized by rapid growth and an increase in chest size and muscle mass in boys. The change in MBC and vital capacity was considered normal, since height and weight are correlated highly with both MBC and vital capacity. The authors recommended that calculations of vital capacity and MBC be based upon age, height, weight, and body surface area rather than upon a prediction derived from a single attribute, especially in the individual who does not have an average height and weight for his age.

Ferris and Smith[1] conducted another study to develop standards for female children and adolescents with respect to MBC and vital capacity. The subjects were 233 healthy girls, aged five through eighteen years, attending three private schools near Boston, Massachusetts. The vital capacities and maximal breathing capacities were measured by means of a Benedict-Roth type spirometer. The largest of three or more measurements of vital capacity and MBC were extrapolated to one minute and then recorded. The age, height, weight, and body surface area of each subject were recorded also.

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[1]Ferris and Smith, "Maximum Breathing Capacity and Vital Capacity in Female Children and Adolescents," 341-351.

The average vital capacities and maximal breathing capacities for the groupings were presented in tabular form. The individual maximal breathing capacities and vital capacities were plotted as scattergrams against age, height, weight, and body surface area. It was noted that unlike the adolescent males, there was no change in the slope of the curves at the time of the adolescent growth spurt. It was implied that the muscular development associated with this growth spurt is less in females than in males.[1]

Correlation coefficients for the MBC and vital capacity in relation to age, height, weight, and body surface area in female children and adolescents were also presented. Each of the individual attributes showed a high positive correlation. The multiple correlation coefficient was 0.75 for MBC and vital capacity, age, height, and weight, and 0.923 for vital capacity and MBC, age, height, and weight. It was concluded that in an individual who does not have an average height and weight for his age, the use of the four physical attributes should give a truer value than any one attribute. For an individual of average size and configuration, the use of any one of the attributes would adequately predict the expected MBC or vital capacity. The use of all four attributes as a basis for prediction would give more stability to the final predicted value.

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[1] *Ibid*., p. 342.

Millman, *et al.*,[1] Franklin[2] and Hyde and Swarts[3] conducted studies to determine the relationship between participation in a physical conditioning program and changes in the MBC of asthmatic children. None of the investigators found significant changes in MBC after the experimental period. The studies are described on pages 38 to 42.

Research Concerning Submaximal Working Capacity-170

The SWC_{170} test has been utilized by a small number of investigators to determine the working capacity of subjects submaximally. A review of the literature revealed an absence of available norms for children aged five through twelve years for SWC_{170}.

Doroschuk[4] conducted a study utilizing 200 high school boys, aged fourteen through seventeen, and 110 men, aged nineteen through sixty, to standardize a short test which determines working capacity. The initial work load on the bicycle ergometer was 150 KPM, and the resistance was increased 150 KPM each minute for four minutes. The heart rate was plotted and the line extrapolated to a heart rate of 170 beats per minute. The Submaximal Work Capacity score

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[1] Millman, *et al.*, "Controlled Exercise in Asthmatic Children," 220-225.

[2] Franklin, "An Experimental Study of Physical Conditioning for Asthmatic Children."

[3] Hyde and Swarts, "Effect of an Exercise Program on the Perennially Asthmatic Child," 383-396.

[4] Doroschuk, "A Short Test of Submaximal Working Capacity (SWC_{170})," 10.

was recorded in terms of KPM. A Pearson Product-Moment coefficient of correlation for test-retest data resulted in .72. A coefficient of validity of .83 was calculated. It was concluded that the resulting values were only slightly larger than those obtained by Sjostrand and Holmgren.

Rosentswieg[1] administered a modification of the SWC_{170} test to approximately 100 college women at the Texas Woman's University in Denton, Texas. A Pearson Product-Moment coefficient of correlation for test-retest data resulted in .96. A coefficient of validity of .60 was calculated. It was recommended that this quick, objective, and reliable test be utilized to measure a subject's capacity to work. The cost of the necessary equipment is small, and motivation is thought to be relatively unimportant.

Lebato[2] conducted a study at the Texas Woman's University in Denton, Texas, to determine the influence of participation in light, moderate, or heavy levels of gross motor activity upon residual neuromuscular tension as measured by quantitative electromyography. The subjects utilized in the study were sixty college women ages seventeen through twenty-two. The initial work load on the

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[1]Joel Rosentswieg, "A Quick, Submaximal, Physical Fitness Test for Women" (paper presented at the Texas Association for Health, Physical Education, and Recreation, Fort Worth, Texas, December 4, 1970).

[2]Loretta Thibodeaux Lebato, "An Electromyographic Study of the Effect of Participation in Three Selected Gross Motor Activities on Residual Neuromuscular Tension" (unpublished Ph. D. dissertation, Texas Woman's University, 1970).

bicycle ergometer was set at 150 KPM, and the resistance was increased 50 KPM each minute for a period of four minutes. The metronome was set at one hundred beats per minute. The heart rate was taken at the end of each minute, and the working capacity was calculated by plotting the heart rate against the work load at the end of each minute. A line of best fit was drawn through the four points. The estimated work corresponding to a heart rate of 170 was recorded as the subject's SWC_{170}. The F values for the physical fitness measurements were not significant; therefore, it was concluded that the subjects in the activity groups did not achieve a statistically significant gain in physical conditioning through participation in the three levels of gross motor activity.

The study by Franklin[1] was the only investigation found to utilize the SWC_{170} test for the determination of working capacity of asthmatic children. An analysis of variance revealed significant differences at the .05 level between the pretest and posttest values for SWC_{170}. A review of the study is found on page 41 of the thesis.

Research Studies of Physical Conditioning and/or Swimming for Asthmatic Children

Since 1956, numerous programs of physical activities for asthmatic children have provided the opportunities for further research with respect to the relationship between

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[1]Franklin, "An Experimental Study of Physical Conditioning for Asthmatic Children."

exercise and changes in the behavior of asthmatic children. Few of these programs, however, have provided for the collection of physiological data through laboratory apparatus and for the statistical treatment of the data collected. The following review of literature is organized under two side headings: Studies which Present Statistical Evidence of Findings and Studies which Present Empirical Evidence of Findings.

Studies which Present Statistical Evidence of Findings

Seligman, Randel, and Stevens[1] conducted two programs of swimming instruction for children with asthma in San Diego, California. Four girls and eight boys, ages nine through twelve, participated in the first program. One girl and seven boys, ages six through ten years, were enrolled in the second program. Each program, conducted for one and one-half hours a week for eight weeks, consisted of practice in conscious relaxation, controlled breathing during activity, games and relays to encourage competition, swimming instruction, and games in the water.

The subjects were tested at the first and last sessions. Pulmonary function studies were performed to determine the vital capacity and one-second forced expiratory volume. Total excursion of the chest was measured in inches at the lower ribs to determine chest mobility, and

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[1]Seligman, Randel, and Stevens, "Conditioning Program for Children with Asthma," 641-647.

pulse rate was counted while walking on a treadmill to measure pulse rate immediately after activity.

The pretest and posttest results revealed no significant change in FEV_1 and vital capacity in both groups. All of the children in the first group and five of the eight children in the second group increased chest mobility. The posttests of the subjects in both groups showed a reduction in pulse rate and a marked improvement in swimming ability. No significant differences between the two groups for the FEV_1 and the vital capacity were found. A comparison of the pulse rates approached the .01 level of significance. There was a significant difference in the results of the chest expansion measurements. It was concluded that the program was beneficial and should be available to every child with asthma.

Chai and Falliers[1] conducted a study at the Children's Asthma Research Institute and Hospital, Denver, Colorado, to determine the value of swimming as a component of rehabilitation therapy of asthma. Thirty asthmatic children participated in the controlled study for a period of twelve weeks, six of which comprised the experimental period during which the subjects swam for forty minutes each day and were required to employ specific breathing procedures. Measurements of the vital capacity and FEV_1 were recorded daily, and each subject was administered a physical

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[1]Chai and Falliers, "Controlled Swimming in Asthmatic Children," 93.

examination twice a week. When the control and active phases were compared, the results indicated no changes in any measurement of pulmonary efficiency.

Chai, <u>et al</u>.[1] conducted a study utilizing patients at the Children's Asthma Research Institute and Hospital in Denver, Colorado. The subjects were thirty children divided into three equal groups. One group performed breathing exercises only, the second group engaged in physical fitness procedures, and the third group was designated as the control group. Each subject had a session with the physical therapist twice daily for twenty minutes. Clinical, historical, and physiological measurements were obtained from each subject. These included a clinical chest evaluation, historical data covering asthma, exercise ability, medication, school attendance, sleep, recordings of vital capacity and FEV_1, treadmill work, pulmonary volumes, and resistance breathing. The experimental period consisted of ten months of control and ten months of study. Each subject acted as his own control and had a matched control in the other two groups.

The investigators indicated that all three groups improved during the experimental period on all variables but no evidence of statistical treatment appeared in the article. It was suggested that physical therapy may not

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[1]Chai, <u>et al</u>., "Long-term Investigation into the Effects of Physical Therapy in Chronically Asthmatic Children," 109.

have contributed to the improvement because the control group showed equal improvement.

Hyde and Swarts[1] appraised the progress of thirty-six asthmatic boys and girls, aged six to fourteen years, in a special outpatient rehabilitation class at the YMCA in Oak Park, Illinois. The children were observed for a period of two years. The class met for one hour once a week during the regular school year. The program consisted of corrective work, breathing exercises using the pursed-lip, slow expiration method, and light endurance work. Pulmonary values for FEV_1, MBC, and total vital capacity were obtained to determine whether exercises would improve or worsen the condition. The results of the tests for FEV_1, MBC, and vital capacity revealed that moderate to marked airway obstruction remained unchanged in one-half of the study periods of three to four months' duration. The conditions of thirteen per cent worsened. Following two successive terms, six to eight months, thirty-five per cent of the patients continued to have moderate to marked obstruction, twenty-three per cent improved, and twenty-six per cent worsened. It was concluded that a complete therapeutic program for perennial asthma should include medical therapy in addition to special exercises to improve the patients' physical capabilities.

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[1]Hyde and Swarts, "Effect of an Exercise Program on the Perennially Asthmatic Child," 383-396.

Hirt[1] conducted a study at the National Jewish Hospital in Denver, Colorado, to evaluate the effects of physical conditioning upon patients with asthma. The subjects utilized in the investigation were sixty-three hospitalized asthmatic patients aged fifteen to twenty-eight years. Twenty-three of the subjects were randomly assigned to a physical exercise group, and the remaining forty subjects were placed in a control group. The experimental period was three months in duration. The control group was restricted from participation in strenuous sports activities, whereas the experimental group received two hours of physical training each day, five days per week. One hour was devoted to exercises with weight resistances, and one hour to sports activity. The FEV_1, vital capacity, maximum oxygen consumption, and external work load of each subject were measured at the beginning of the experimental period and at the conclusion of three months. The two groups were found to be equated upon every variable, and each subject demonstrated a considerable degree of pulmonary obstruction. The control and experimental groups had an FEV_1 which was significantly lower than normal when compared to the norms obtained by Strang.

The results of the performance of each group at the conclusion of three months revealed that there were no significant changes in the degree of airway obstruction in the

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[1]Hirt, "Physical Conditioning in Asthma I," 229-237.

subjects. There were, however, changes in FEV_1, but they did not represent a statistically significant improvement. Each subject in the experimental group showed a significant increase in the remaining variables. The patients in the control group showed a significant increase only in their work load. Hirt could not account for the increase. It was concluded that "strenuous physical exercise does not seem detrimental to patients with severe asthma and that such patients respond very similarly to normal subjects exposed to physical training."[1]

Millman, _et al_.[2] conducted a study to evaluate the effect of a controlled exercise program upon asthmatic children in the areas of respiratory function, cardiovascular efficiency, physical performance, and personality. The subjects utilized in the investigation were seven asthmatic boys and two asthmatic girls who ranged in age from seven to twelve years. The exercise program was presented in the gymnasium of San Diego State College, where every attempt was made to keep the environmental factors constant. The subjects participated in the program for a period of four months, three times a week for forty-five minutes. The program consisted of warm-up exercises, breathing exercises, cardiorespiratory conditioning, and vigorous games and sports.

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[1] _Ibid_., p. 237.

[2] Millman, _et al_., "Controlled Exercise in Asthmatic Children," 220-225.

Prior to and after completion of the exercise program, pulmonary function was evaluated by testing FEV_1, vital capacity, and MBC by means of a 13.5 liter Collins Respirometer. The results revealed that the pretest and posttest FEV_1 values remained essentially unchanged. The mean group values demonstrated a fifty-five to eighty-nine per cent increase in the MBC. The vital capacity improved only seven per cent on the average. The California Personality Test administered to the subjects revealed a lack of change. It was suggested that a program of regular exercise with promotion of good general physical conditioning performed under guidance at regular intervals was extremely beneficial to asthmatic children. It was concluded also that controlled exercise should be part of the treatment of asthma, combined with proper allergic management.

Franklin[1] conducted a study at the Texas Woman's University to determine the relationship between the participation in a physical conditioning program and the changes in pulmonary efficiency and working capacity of twenty-six asthmatic children, ages six through fifteen years, in Denton, Texas, during the summer of 1970. The experimental group, comprised of thirteen asthmatic boys and girls, participated in a program of physical conditioning five days a week for a period of four weeks. The control group, comprised of thirteen asthmatic boys and girls, adhered to their routine daily living activities.

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[1]Franklin, "An Experimental Study of Physical Conditioning for Asthmatic Children."

Prior to and after completion of the experimental period, pulmonary efficiency was measured by the one-second forced expiratory volume (FEV_1) and maximal breathing capacity (MBC), as determined by means of a 13.5 liter Collins Respirometer; and submaximal working capacity (SWC_{170}) was estimated by means of a bicycle ergometer. A one way analysis of variance, computed for each of the three tests, revealed that there was no significant difference between the values on the pretests and posttests with respect to FEV_1, MBC, and SWC_{170}. There was a significant difference, however, between the pretest and posttest values of the experimental group with respect to SWC_{170}.

The Wilcoxon Sign Test, selected to determine significant trends, revealed that the experimental group had significant differences between the number of increased and decreased values at the .01 level for the FEV_1 test, the MBC test, and the SWC_{170} test, whereas the control group had no significant differences between the number of increased and decreased values. It was concluded that participation of asthmatic children in a program of physical conditioning for four weeks contributed to a significant increase in working capacity but did not significantly change pulmonary efficiency.

Taylor, et al.[1] tested the influence of rigorous and organized swim training upon thirteen institutionalized

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[1]William F. Taylor, et al., "Swim Training: Its Effect on Asthmatic Children," Journal of Allergy, XLI (February, 1968), 92.

asthmatic children in Los Angeles who were classified as beginner swimmers. The subjects were trained by a physical education instructor for one hour a day for a period of six weeks. The crawl stroke, endurance, race diving, and breathing were emphasized. Once a week, the children were required to engage in ten minutes of continuous swimming. Wright Peak Flow Rates (WPFR) were taken before, during, and immediately following the ten-minute swim. Each child's speed in the thirty-yard freestyle was also recorded weekly.

The results showed that, as a group, the time required to swim thirty yards improved twenty-five per cent, but the WPFR showed no significant improvement. The personnel at the institution reported marked improvement, however, in appetite, sleep, and behavior of each subject.

Itkin and Nacman[1] conducted a study at the National Jewish Hospital in Denver, Colorado, to investigate the immediate and prolonged effects of a continuous and vigorous physical conditioning program upon asthmatic patients. The subjects, twenty-nine males and ten females between the ages of fifteen and thirty-five years, were patients of the hospital and suffered from perennial asthma. Twenty-nine subjects were assigned to the control group for three months, during which time each was allowed to participate in normal hospital activities but was not permitted additional physical exertion. Following the control period, all subjects

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[1]Itkin and Nacman, "The Effect of Exercise on the Hospitalized Asthmatic Patient," 253-263.

participated in a three-month period of exercise consisting of calisthenics and planned sports activity two hours a day, five days a week. A second group consisting of ten subjects participated in the exercise program for three months, and then observed a three-month control period.

The FEV_1 of each subject was taken daily on a spirometer. The mean FEV_1 of each group was below the predicted mean FEV_1 for that group.

Prior to the control period, at the end of three months, and at the conclusion of the investigation, each subject was tested on the treadmill to determine the effects of the physical conditioning program. In addition, FEV_1 was recorded immediately before and after the patient exercised on the treadmill.

The _t_ test revealed that sixteen subjects who engaged in the exercise program had a significant increase in FEV_1, and three patients had a significant decrease in FEV_1. All subjects had less than a fifteen per cent change in FEV_1 at the end of three months of control. There were no differences in the recordings of males as compared with females.

The majority of subjects gave evidence of increased ability to perform on the treadmill. There were no differences noted between treadmill performance by subjects in the two groups at the end of the control period or the activity period. It was suggested that forms of intermittent exercise such as ball games were much more suitable for the asthmatic child than constant exercise. It was concluded that physical conditioning may be indicated for a large number of subjects with asthma in an attempt to increase the usefulness of their lives.

McElhenney and Petersen[1] conducted a pilot study at the University of Texas, Austin, Texas, to determine if a carefully planned physical fitness program would decrease the physical and emotional handicaps of asthmatic children. The subjects comprising the study were twenty boys, aged eight through twelve years, suffering from moderate to severe bronchial asthma.

The boys participated in the program twice a week for a period of four months. The program, which emphasized the development of fitness and the improvement of basic body skills, consisted of calisthenics, games and relays, competitive lead-up games, tumbling, weight training, and swimming.

Measurements of lung capacity were taken prior to and at the culmination of the program by means of the vital capacity test. Psychological testing was conducted prior to and immediately upon completion of the pilot study. The two instruments utilized were the Children's Form of the Taylor Manifest Anxiety Scale and The Children's Personality Inventory.[2]

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[1]Thomas R. McElhenney and Kay H. Petersen, "Physical Fitness for Asthmatic Boys," Journal of the American Medical Association, CLXXXV (July 13, 1963), 142-143.

[2]Consulting Psychologists Press, Inc., 270 Town and Country Village, Palo Alto, California.

The t test for the significance between means was used in the treatment of the data. The average increase in vital capacity was eighteen per cent, which was significant at the .01 level of confidence. There were no significant differences with respect to personality as determined by the two psychological tests. It was concluded that remedial or adapted programs of physical education are important in the treatment of asthmatic children, and should be encouraged in each community.

Petersen and McElhenney[1] conducted a study to determine the effects of a physical fitness program upon twenty asthmatic boys in Austin, Texas, during the academic year of 1962-1963. The purpose of the investigation was to examine the hypothesis that a carefully designed and competently guided program to develop physical fitness and to enhance abilities of asthmatic boys in various skills would develop self-reliance as well as physical fitness, and lessen emotional stress and frequency of attacks.

The subjects in the study were twenty boys, aged eight through thirteen years, suffering from moderate to severe bronchial asthma. All of the subjects participated in the rehabilitation program, which met for one hour three times a week for a period of eight months. The program consisted of calisthenics, relays and games of simple

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[1]Kay H. Petersen and Thomas R. McElhenney, "Effects of a Physical Fitness Program Upon Asthmatic Boys," Pediatrics, XXXV (February, 1965), 295-299.

organization, skills and lead-up games to team sports, and graded stunts, self-testing activities and tumbling.

Data were collected before and after the experimental period with respect to the following variables: (1) physical fitness as measured by the 50-yard dash, standing broad jump, sit-ups, softball throw, agility run, pull-ups, grip strength, and rope climb; (2) vital capacity as measured by the wet spirometer and the McKesson Vitalor; (3) school attendance; (4) parents' evaluations as measured by a questionnaire; (5) public school teachers' evaluations as measured by a questionnaire; (6) psychological status as measured by the Children's Personality Questionnaire;[1] and (7) allergist's evaluation as measured by a questionnaire.

An analysis of variance revealed that the difference between the mean scores of vital capacity and of physical fitness was significant at the .01 level of confidence. It was noted that the greatest improvement occurred in the first four months of the program.

A comparison was made between the total number of days absent from school by the subjects for the academic years of 1961-1962 and 1962-1963. A total number of 185 days of school was missed during the year of 1961-1962 as compared with 69 days during the year of the boys' participation in the program.

An analysis of the parents' evaluations revealed that sixteen of the twenty parents stated there had been

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[1]Consulting Psychologists Press, Inc., 270 Town and Country Village, Palo Alto, California.

a reduction in number and severity of asthmatic attacks. Fifteen parents stated emotional upsets had decreased while only one reported an increase. Eighty per cent of the classroom teachers indicated that the children had improved in the acceptance by other children and in emotional stability.

Conclusions drawn from an analysis of the composite scores of the children yielded by the Children's Personality Questionnaire revealed improvement in group activity and sociability. Participation in the program appeared to enhance the subjects' relationships with their peers.

Studies which Present
Empirical Evidence of Findings

Scherr and Frankel[1] reported on the program of physical activities that was started in 1956 at the Charleston, West Virginia, Young Men's Christian Association. The program combined teaching of breathing exercises with physical conditioning exercises on a level which was designed for the individual child. The first group of participants were six boys suffering from moderate to severe asthma. The program consisted of exercises performed in game style, respiratory exercises as outlined by the Asthma Research Council of London, gymnastics, and swimming. Combative activities were taught in an attempt to develop confidence. The progress of each child was recorded.

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[1]Merle S. Scherr and Lawrence Frankel, "Physical Conditioning Program for Asthmatic Children," Journal of the American Medical Association, CLXVIII (December 13, 1958), 1996-2000.

In 1957, the program was enlarged to include girls, and the class was limited to twenty-five children between the ages of six and fourteen years. The children met two afternoons a week, and the program was divided into basic breathing techniques, postural exercises, gymnastic activities, combative activities, and calisthenic drills. Swimming was an important part of the program because it combined the use of all muscle groups with practical breathing functions.

Participation in the conditioning program resulted in a marked decrease in the frequency and severity of asthmatic attacks of the subjects. None of the children required hospitalization for bronchial asthma after joining the program. According to the authors, "Pulmonary function studies also revealed improvement."[1] No further information was offered as to the pulmonary function studies utilized and the statistical treatment employed. It was stated that the improvement was "due primarily to enlightenment of the child and parents concerning bronchial asthma which resulted in better cooperation with the physician and treatment."[2]

In 1965, the Respiratory Disease Committee of the Tuberculosis and Health Association of Hennepin County,

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[1] *Ibid.*, p. 1999.

[2] *Ibid.*

Minneapolis, Minnesota,[1] developed a physical conditioning program for asthmatic children. The program was planned to serve as an adjunct to the treatment of non-specific factors, particularly those resulting from extended isolation from recreational and social activity.

Thirteen children between the ages of six and fourteen participated in the program. Sessions comprised of planned activities for both children and parents were held once a week for twelve weeks. The exercise program for the children included specific breathing exercises, general body conditioning, postural exercises to strengthen the chest wall, and swimming. The children, who reported that they enjoyed the swimming phase of the program the most, seemed to view it as a reward for other forms of exercising. While the children participated in the exercise sessions, the parents engaged in group discussions.

The progress of the children was judged upon the basis of improved level in physical activity, presence and severity of asthmatic symptoms, school attendance, participation in outside activity, and improvement with respect to lung function. The results of the program showed that the eleven children who completed the course improved in some way, and none experienced exacerbation of symptoms during the course. The majority of the subjects showed an increase

[1]Tuberculosis and Health Association of Hennepin County, "Physical Conditioning Program for Asthmatic Children," Journal of School Health, XXXVII (February, 1967), 107-110.

in tolerance for exercise. Several swam for the first time, and some participated in physical education classes for the first time. The records showed that school attendance improved, a significant number of children needed less medication than in previous years, and several of the children were able to prevent impending asthma attacks through the utilization of the breathing exercises. All of the data collected during the study were qualitative; hence the findings were not substantiated by statistical evidence.

It was concluded that the established physical conditioning program for the child with asthma was both successful and beneficial. All of the parents expressed interest in repeating the program, and the personnel involved in planning and implementing the course agreed that the program filled a definite need in the community and should be continued.

Summary

The disease called "asthma" is as old as known history. It was described in ancient literature, and various symptoms were described. The literature does not reveal great advances, however, until the nineteenth century, when the concept of allergy was developed. The current trend is the treatment and prevention of asthma through immunology, or injections of antitoxins.

The Committee on Children with Handicaps, Itkin, and Hirt reported that strenuous exercise has not been found to be detrimental to persons with asthma. The asthmatic individual responds in much the same manner as the healthy person when exposed to physical activity, so he should be given equal opportunity to benefit from exercise.

The diaphramatic breathing exercises utilized by numerous physicians in the treatment of asthma were presented and described in studies by Livingstone, Fein & Cox, Livingstone & Gillespie, and May. Subjects employing breathing exercises in those studies did not yield statistically significant results following treatment. There were, however, psychological improvements cited in the four studies. Every investigator agreed that breathing exercises should be learned and practiced only in conjunction with medical treatment.

In this chapter of the thesis, related literature was reviewed under the following center headings: Research Concerning One-second Forced Expiratory Volume, Research Concerning Maximal Breathing Capacity, Research Concerning Submaximal Working Capacity-170, and Research Studies of Physical Conditioning and/or Swimming for Asthmatic Children.

The test for FEV_1 is utilized extensively to determine pulmonary function before and after exercise. Numerous studies have been conducted to investigate the relationship between participation in physical exercise and changes in FEV_1. Subjects in studies by Seligman, Randel, and Stevens; Chai and Falliers; Chai _et al_.; Hyde and Swarts; Hirt; Millman _et al_.; and Franklin yielded FEV_1 values that were not statistically significant. The investigation by Itkin and

Nacman was the only one comprised of subjects who yielded pretest and posttest values for FEV_1 that were found to be statistically significant. Beaudry, Wise, and Seely, and Capel and Smart found that the greatest mean increase between pretest and posttest values was obtained immediately following exercise in subjects with airway obstruction. The FEV_1 values of healthy subjects showed no increase following exercise. The investigators agreed that the FEV_1 recordings of the asthmatic subjects correlated with the severity of the disease and were significantly lower than normal standards.

The MBC test has been found to correlate more closely with dyspnea than any other test of pulmonary efficiency. Predictions of MBC values should be based upon age, height, weight, and body surface area, as studies by Ferris, Whittenberger, & Gallagher, and Ferris & Smith have indicated a high intercorrelation between MBC and those four physical attributes. Studies that have been conducted by Millman et al., Franklin, and Hyde & Swarts to determine the relationship between participation in programs of physical conditioning and changes in MBC of asthmatic children have revealed no significant differences in pretest and posttest values.

The studies by Doroschuk, Rosentswieg, and Lebato employed the SWC_{170} test to determine the working capacity of adult subjects. Of the four studies cited, Franklin's investigation was the only experimental study comprised of asthmatic children. The SWC_{170} test in that study revealed a significant difference between the pretest and posttest values of the experimental group.

Organizations such as the YMCA in Oak Park, Illinois, and Charleston, West Virginia, and the Respiratory Disease Committee of the Tuberculosis and Health Association of Hennepin County, Minneapolis, Minnesota, have developed programs of physical conditioning and swimming to aid in the treatment of asthma. The asthmatic child is encouraged to participate in healthy physical activity that he may otherwise forego because of his illness. Participation in such programs has been shown to help the asthmatic child gain the physical capacity, confidence, and initiative necessary to lead a full life. McElhenney and Petersen's report on a program of physical fitness cited significant differences in pretest and posttest values for a pulmonary efficiency test and a series of physical fitness tests of asthmatic children. In addition, the parents and teachers of those children reported subjective improvements. Seligman, Randel, and Stevens studied changes in asthmatic subjects following physical conditioning programs and reported increases in chest mobility and swimming ability. Itkin found a significant change in FEV_1 of asthmatic subjects as the result of an exercise program. Franklin found a significant difference in the pretest and posttest values on working capacity of asthmatic children following a program of physical conditioning. No significant changes in pulmonary efficiency were reported by Chai and Falliers and Taylor et al. in subjects as the result of swimming programs. Every investigator agreed that exercise and physical education activities are important, and should be part of the treatment and rehabilitation of children with asthma.

Chapter III includes a description of procedures employed in the development of this study.

CHAPTER III

PROCEDURES FOLLOWED IN THE DEVELOPMENT OF THE STUDY

The present study entailed an investigation of changes in pulmonary efficiency and working capacity of fifty-six asthmatic and non-asthmatic children in a daily swimming program of four weeks' duration. In this chapter of the thesis, procedures followed in the conduct of the study will be described under the following center headings: Preliminary Procedures, Selection of the Subjects, Selection and Description of the Instruments, Planning and Conducting the Swimming Program, Collection of Data, Treatment of Data, and Preparation of the Final Written Report.

Preliminary Procedures

Prior to the actual collection of data, a series of preliminary procedures was completed. Permission was secured from the Dean of the College of Health, Physical Education, and Recreation at the Texas Woman's University in Denton, Texas, to conduct the study. The investigator surveyed, studied, and assimilated information germane to all aspects of the present study from all available documentary and human sources of data. Interviews concerning the diagnosis and treatment of asthma were conducted with qualified pediatricians for the purpose of obtaining information not available in documentary sources.[1]

The Tentative Outline for the thesis was developed and presented in a Graduate Seminar of the College of Health, Physical Education, and Recreation at the Texas Woman's University in Denton, Texas, on July 2, 1971. A copy of the revised and approved outline of the study was filed in the form of a Prospectus in the Office of the Dean of Graduate Studies at the Texas Woman's University.

Selection of the Subjects

The parents of known asthmatic children were contacted by telephone, the proposed swimming program was described, and their participation in the program was solicited. A copy of the letter, including the application blank which was developed and sent to the parents who indicated an interest in the program, appears in the Appendix of the thesis.

The investigator contacted the local newspaper, and a feature article describing the program was placed in the May 31, 1971, issue of the Denton Record-Chronicle. A copy of this article appears in the Appendix. The names and addresses of the persons who called in response to the

[1]Interviews with Dr. Jack E. Strange, M. D., New Orleans, Louisiana, May 30, 1971; Dr. Michael Sly, M. D., New Orleans, Louisiana, May 31, 1971; Dr. Howard Russell, M. D., New Orleans, Louisiana, May 31, 1971; and Dr. Marjorie Keele, M. D., Denton, Texas, May 13, 1971.

article were recorded, and letters and application blanks were mailed to them.

A personal data sheet and medical form were developed and mailed to the parents who returned the application blanks. A copy of the personal data sheet, parental permission blank, and medical clearance form appear in the Appendix of the thesis. The parents who did not return the application blanks by the deadline were contacted by telephone to confirm their interest or lack of interest in the study.

The following criteria were established for the selection of subjects: (1) the subjects must be asthmatic or non-asthmatic children residing in Denton, Texas, (2) the subjects must range from five through twelve years of age, (3) the parents of the asthmatic and non-asthmatic children must give written permission for their child to perform the two tests for pulmonary efficiency and the test for working capacity before and after the swimming program, (4) the parents of the asthmatic and non-asthmatic children must give written permission for their child to participate in the swimming program, and (5) the subjects must have a medical form completed and signed by their physician.

The subjects selected in accordance with the criteria established included thirty asthmatic and thirty non-asthmatic boys and girls between the ages of five and twelve years. The matched-pairs technique[1] was employed to assign

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[1]Doebold B. Van Dalen, Understanding Educational Research (New York: McGraw-Hill, Inc., 1966), p. 259.

each asthmatic subject a non-asthmatic partner of identical age, sex, and swimming ability. The asthmatic subjects were randomly assigned to one of two groups, and the non-asthmatic subjects were randomly assigned to one of two groups. The experimental and control groups were determined by random selection, i.e., by flipping a coin.

Prior to the experimental period, several one way analyses of variance were computed to determine if there were any significant differences between subjects in the four groups with respect to age, height, weight, FEV_1, MBC, and SWC_{170}. In the event of a significant F ratio, the Duncan's Multiple-Range Test was selected as the subsequent test to determine where the significant differences occur. The resulting F ratios showed no significant differences; therefore, the groups were considered equated. The data appear in the Appendix of the thesis.

Prior to the conclusion of the experimental period, four subjects found it necessary to discontinue their participation in the study. One girl six years of age in the asthmatic experimental group suffered from severe asthmatic attacks and was hospitalized; a girl eleven years of age in the non-asthmatic experimental group and a boy eight years of age in the non-asthmatic control group experienced a sudden change in vacation plans that conflicted with the experimental period; and a girl nine years of age in the asthmatic control group moved away from Denton, Texas. An analysis of variance revealed that the loss of four subjects did not affect the initial equating of the groups with respect to FEV_1, MBC, SWC_{170}, height, weight, swimming ability, and asthmatic status. The equation of boys and girls, and the mean age of the subjects in the four groups, however, were altered as a result of the depletion. The number of boys in the non-asthmatic control group, and the number of girls in the remaining groups were decreased one number. An analysis of variance with respect to age computed at the beginning of the experimental period resulted in an F ratio that was not significant at the .05 level. Following the loss of the four subjects, the resulting F ratio was found to be significant at the .05 level, and it was acknowledged that the groups were no longer equated with respect to age.

At the conclusion of the study, the subjects who participated in the swimming program included nine boys and five girls in the asthmatic group, and nine boys and five girls in the non-asthmatic group. The subjects in the control group included eight boys and six girls in the asthmatic group, and seven boys and seven girls in the non-asthmatic group. The mean ages for the subjects were 9.01, 7.16, 7.49, and 8.65 for the asthmatic experimental, non-asthmatic experimental, asthmatic control, and non-asthmatic control groups respectively, as compared to 8.39, 7.64, 7.86, and 8.27 before the four subjects dropped out of the study.

Selection and Description of the Instruments

The investigator reviewed extensively the available instruments which would provide a means of determining the changes in pulmonary efficiency and working capacity of asthmatic and non-asthmatic children, aged five through twelve years, in a swimming program. The criteria established for the selection of the instruments to be utilized in the collection of data before and after the swimming program were reliability, validity, objectivity, availability of norms, ease of administration, availability of equipment, adaptability for children, safety of subjects, and simplicity of performance. The instruments selected in accordance with the criteria established were Forced Expiratory Volume for one second (FEV_1),[1] Maximal Breathing Capacity (MBC),[2] and Submaximal Working Capacity-170 (SWC_{170}).[3]

The Collins 13.5 liter Respirometer was used to collect data for both the FEV_1 and MBC in the present study. A rubber mouthpiece, a noseclip, two bottles of ink, a ruler, and alcohol to cleanse the mouthpiece were necessary also. The Respirometer is comprised of a hose attached to

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[1] Pierre DeJours, Respiration (New York: Oxford University Press, 1966), p. 54.

[2] Gaensler and Wright, "Evaluation of Respiratory Impairment," 155.

[3] Doroschuk, "A Short Test of Submaximal Working Capacity (SWC_{170})," 10.

an inverted, water-sealed container which is counterweighted. The container is accurately counter-balanced by a chain which passes over a free running pulley and is attached to a pen which records fully all respiratory movement of volumes of gas. Mounted on top of the pully is the Reichart ventilometer which moves a second pen. A reduction gear reduces the movement of the second pen to one twenty-fifth of the regular pen, and records only the inspiratory activity. The respiration pen and the ventilometer pen record the action of the container with red ink and black ink, respectively, on Collins Kymograph paper, which is attached to the revolving kymograph, a large aluminum drum. The kymograph moves by three individual motors which rotate it at 32, 160, or 1920 millimeters per minute. In this study, to record FEV_1, the respiration pen was placed on the kymograph and the speed of the kymograph was set at 1920 millimeters per minute. To record MBC, the ventilometer pen was placed on the kymograph and the speed of the kymograph was set at 160 millimeters per minute.

One-second Forced Expiratory Volume

The FEV_1 is the volume of air forcefully exhaled in the first second after a full inspiration per unit time.[1] In the present study, the Collins 13.5 liter Respirometer yielded a value in cubic centimeters of gas exhaled in one second.

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[1]Homayoun Kazemi, "Pulmonary-Function Tests," 2302.

The validity of the FEV_1 for the measurement of pulmonary efficiency of asthmatics was substantiated by Cotes,[1] who stated that FEV_1 is a reproducible and simple test that varies with the degree of bronchial obstruction. Kazemi[2] agreed that diseases such as asthma which cause obstruction and resistance of the bronchial airways reduced FEV_1. He recommended the utilization of FEV_1 for patients with obstructive lung disease and stated that FEV_1 is "relatively easy to perform and provides significant information as a screening test or for evaluation of patients with lung disease."[3] The test was easily performed by the subjects in the present study.

According to Cotes,[4] the highest correlation with FEV_1 is with MBC. A close relationship between FEV_1 and MBC was also shown by Gaensler[5] with a coefficient of correlation of .88.

Franklin[6] computed a coefficient of reliability for FEV_1 of .968 through the test-retest method. The sample was comprised of thirty children aged six through thirteen years.

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[1]J. E. Cotes, Lung Function (Philadelphia: F. A. Davis, 1965), p. 104.

[2]Kazemi, "Pulmonary-Function Tests," 2303.

[3]Ibid., p. 2302.

[4]Cotes, Lung Function, p. 99.

[5]Edward A. Gaensler, "Analysis of the Ventilation Defect by Timed Capacity Measurements," American Review of Tuberculosis, LXIV (September, 1951), 256-278.

[6]Franklin, "An Experimental Study of Physical Conditioning for Asthmatic Children."

The coefficient of reliability for FEV_1 for the sample in the present study as calculated through the test-retest method by the investigator within a period of four days was .92 for the entire group, .95 for thirty asthmatic subjects, and .89 for the thirty non-asthmatic subjects.

Maximal Breathing Capacity

The MBC is the maximum volume of air which the subject can move per minute when breathing as deeply and rapidly as possible.[1] The volume of gas is expressed in liters per minute as yielded by the Collins 13.5 liter Respirometer.

The validity of MBC for measuring pulmonary efficiency of asthmatic persons was supported by Kazemi[2] who recommended MBC for "a screening test or for evaluation of patients with lung disease."[3] He also stated that MBC is reduced in obstructive lung disease since the test depends on rapid expiratory air flow. Gaensler and Wright[4] agreed that the MBC correlated more closely with dyspnea than does any other test. Performance of this test is dependent upon several factors including muscular force, compliance of the

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[1]Cotes, Lung Function, p. 96.

[2]Kazemi, "Pulmonary-Function Tests," 2302-2303.

[3]Ibid., p. 2302.

[4]Gaensler and Wright, "Evaluation of Respiratory Impairment," 155.

lungs and thoracic cage, in addition to the resistance of the airway and the pulmonary and thoracic tissues.[1] According to Cotes,[2] the maximum breathing capacity is correlated to the extent of 0.75 to 0.95 with F.V.C., I.M.B.C., and FEV_1, and the highest correlation is with FEV_1.

Franklin[3] computed a coefficient of reliability for MBC of .815 through the test-retest method. The sample was comprised of thirty asthmatic children aged six through thirteen years.

The coefficient of reliability for MBC for the sample in the present study as calculated through the test-retest method by the investigator was .85 for the entire group, .87 for thirty asthmatic subjects, and .82 for thirty non-asthmatic subjects.

Submaximal Working Capacity-170

The SWC_{170} test[4] determines the estimated amount of work that corresponds to a heart rate of 170 during exercise on a bicycle ergometer. The heart rate rises with increased workloads at submaximal levels to the point of maximum efficiency. In the present study, the initial workload of

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[1]Millman, et al., "Controlled Exercise in Asthmatic Children," 222.

[2]Cotes, Lung Function, p. 99.

[3]Franklin, "An Experimental Study of Physical Conditioning for Asthmatic Children."

[4]Doroschuk, "A Short Test of Submaximal Working Capacity (SWC_{170})," 10.

150 KPM (kilopond meters) was increased 150 KPM each minute for four minutes or until the subject's heart rate reached 170 beats per minute. The test stops when the heart rate of the subject reaches 170 beats per minute because this may be accepted as a level close to which the heart is working at maximum efficiency, and above which no significant increase in workload occurs.[1,2]

The Monark bicycle ergometer,[3] Crystalab metronome,[4] Medetron electronic stethoscope, language lab record player, and a stopwatch were used in the administration of the SWC_{170} test. The bicycle ergometer is described as a stationary bicycle with a flywheel which is restrained by a friction belt. The metronome, a device that beats time and produces a clicking sound, was set at fifty double-beats per minute. The electronic stethoscope, which amplifies the heart beats of the subjects, was attached to the record player so that each heart beat could be clearly audible to the investigator.

Bengtsson[5] conducted a study to obtain norms for submaximal exercise intensities in normal children and to

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[1]deVries, Physiology of Exercise, p. 206.

[2]Elias Bengtsson, "The Working Capacity in Normal Children, Evaluated by Submaximal Exercise on the Bicycle Ergometer and Compared with Adults," Acta Medica Scandinavica, CLIV (1956), 94.

[3]Quinton Instruments, 3051 44th Avenue West, Seattle, Washington.

[4]Crystal Research Laboratories, Inc., 29 Allyn Street, Hartford, Connecticut.

[5]Bengtsson, "The Working Capacity in Normal Children," 91-109.

correlate the working capacity with age, sex, and body weight. The subjects utilized in the study were 133 males and females aged three to forty years. Bengtsson found that working capacity increased linearly with age throughout childhood, and that heart rate increased linearly with exercise intensity up to 170 beats per minute.

The coefficient of reliability for the SWC_{170} test, as computed by Franklin[1] in a pilot study with a sample of thirty children, aged six through thirteen years, was .883. Rosentswieg[2] calculated for the SWC_{170} test a coefficient of reliability of .96 by the test-retest method, using 105 university women at the Texas Woman's University in Denton, Texas. The coefficient of validity for college age women as evidenced by Rosentswieg was .60. The SWC_{170} was recommended as a quick, objective, and reliable test to measure maximum capacity to work under aerobic conditions.

The seat on the bicycle ergometer was found to be too high for the subjects five years of age. The SWC_{170} test for working capacity, therefore, was not performed by the twelve subjects who were five years old. The coefficient of reliability for the SWC_{170} test as computed by the investigator in using the test-retest method with forty-eight subjects in the study, aged six through twelve years, was .86.

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[1]Franklin, "An Experimental Study of Physical Conditioning for Asthmatic Children."

[2]Rosentswieg, "A Quick, Submaximal, Physical Fitness Test for Women," 1.

Planning and Conducting the Swimming Program

The experimental period consisted of a program of swimming that was conducted for twenty sessions, five days a week, from June 14, 1971, through July 9, 1971. The sessions were presented Monday through Friday from 3:00 to 4:00 P.M. by the investigator and selected assistants at the indoor swimming pool of the College of Health, Physical Education, and Recreation at the Texas Woman's University in Denton, Texas. The water in the swimming pool was maintained at a temperature ranging from 84 to 88 degrees, and the enclosed deck area was approximately 90 degrees.

The specific objectives of the swimming program were: (1) to increase breathing capacity, (2) to teach controlled breathing before and during activity, (3) to teach basic breathing exercises for maximum use of respiratory muscles, (4) to teach the use of the breathing exercises to stop an asthmatic attack, and (5) to develop physical endurance so that each child will be better equipped to participate in regular activities.

Prior to the beginning of the experimental period, the investigator met with eight selected assistants. The swimming program was described, the methods of teaching were explained, questions were answered, and suggestions were reviewed. The investigator showed the motion picture

The Hidden Tear[1] to the assistants so that they would better understand the asthmatic child's problems and needs.

The daily lesson plans for the swimming program appear in the Appendix of the thesis. At the beginning of each session, the roll was called, and the subjects practiced the abdominal breathing exercises based upon the exercises as outlined by the Asthmatic Research Council of London,[2] Fein and Cox,[3] and Livingstone and Gillespie.[4] Swimming instructions as recommended by the American Red Cross[5] were given, with emphasis upon proper breathing techniques and relaxation in the water. Games involving blowing and fast swimming were played until the end of the session.

At the conclusion of two weeks, the investigator contacted the parents of each subject in the experimental group by telephone. The swimming program was discussed and evaluated, and suggestions were requested. Each parent had favorable opinions of the program, and no ideas for improvements were offered.

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[1]The Hidden Tear, Warner-Chilcott, 202 Tabor Road, Morris Plains, New Jersey.

[2]Asthma Research Council, Physical Exercises for Asthma (London: Headley Brothers, 1934).

[3]Fein and Cox, "The Technique of Respiratory and Physical Exercise in the Treatment of Bronchial Asthma," 377-384.

[4]Livingstone and Gillespie, "The Value of Breathing Exercises in Asthma," 705-708.

[5]The American National Red Cross, Swimming and Water Safety Textbook (U.S.A.: The American National Red Cross, 1968).

The investigator met with her assistants periodically to discuss and evaluate the program and each of the subjects in the experimental group. Progress was noted on a chart that was displayed so that every child could see his improvement. The chart was found to be an excellent motivational device.

At the conclusion of the four weeks, American Red Cross certificates and pins were awarded to those subjects who had completed the requirements for Beginner Swimmer and/or Advanced Beginner Swimmer. In addition, each subject received a special award in the shape of a fish for participating in the swimming program.

Collection of Data

Prior to the actual collection of data, numerous procedures were necessary. The investigator devised individual score cards that were used in recording data from the initial and final administrations of the tests. Instructions for the performance of the tests were written so that they could be adapted and clearly understood by the various age groups. The investigator contacted the parents of each subject by telephone and made an appointment for a testing period of thirty minutes.

When the subjects arrived for the tests, the parents were asked to remain outside the testing room. The height and weight of each subject were determined and recorded on the subject's score card. The investigator then read the instructions and explained them in the same manner to each subject, adapting them to the particular age level.

Each subject first performed the test for FEV_1. The noseclip was applied, the subject placed his mouth over the rubber mouthpiece on the Collins 13.5 liter Respirometer, and two trials for practice were taken. The subject breathed normally for a few breaths, and then took a deep breath and exhaled the gas in the lungs as forcefully and rapidly as possible. This procedure was repeated three times.[1]

The subject rested while listening to the instructions for the MBC test. The noseclip was again applied, and the subject placed his mouth upon the rubber mouthpiece and breathed as deeply and rapidly as possible for twelve seconds. The test was repeated for a second time following a period of rest. The rubber mouthpiece was thoroughly cleansed with alcohol.

The subject sat quietly for five minutes, and then the heart rate was recorded in a sitting and standing position. The subject mounted the seat of the bicycle ergometer, and the length from the heel of the shoe to the floor with straight legs was measured with a ruler. The seat was adjusted individually so that the length from the heel to the floor was between six and one-half and seven and one-half inches, to hold the mechanical advantage constant for each subject. The subject rotated the pedals in time with

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[1]S. Freedman and K. Prowse, "How Many Blows Make an $F.E.V._{1.0}$?" The Lancet, II (September 17, 1966), 618-619.

the metronome and stabilized the speed to twenty-three miles per hour for the four minutes. The tension upon the flywheel was set at 150 KPM for the first minute, and the workload was increased 150 KPM at the end of each minute. This resulted in a workload of 600 KPM for the fourth minute of exercise. The stopwatch was started at the beginning of the test, and the subject continued to exercise for four consecutive minutes or until his heart rate reached 170 beats per minute. The heart rate of each subject was recorded for the last fifteen seconds of each minute.

The raw data, which appear in the Appendix of the thesis, were derived in the following manner. The Collins kymograph paper revealed the recordings of the volume of gas in cubic centimeters for the trials of each subject on the FEV_1 and MBC. The value in cubic centimeters for the time interval was obtained through the use of the Segal-Herschfus vital capacity timed interval ruler. The best value of the three performances of FEV_1 was corrected to BTPS and recorded. The better of the two efforts of MBC was multiplied by the ventilograph ratio factor of twenty-five, converted from seconds to minutes, and corrected to BTPS. The required factor for any given spirometer temperature for correction of the gas volume to BTPS was obtained from a chart.[1]

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[1]Clinical Spirometry (Braintree, Massachusetts: Warren E. Collins, Inc., 1957), p. 27.

For the SWC_{170} test, the heart rate for the last fifteen seconds of each minute of exercise was multiplied by four to obtain the heart rate for the minute. For each child, the values were plotted on the graph of the score card. These values were essentially linear. A line was drawn through the points to intersect the line of 170 beats per minute. The number of seconds required for the heart rate to reach 170 beats per minute was extrapolated.

The tests for FEV_1, MBC, and SWC_{170} were administered again at the completion of the swimming program in accordance with the same procedures followed at the beginning of the study. Each subject in the control and experimental group of the study was cooperative and returned at the scheduled time for the tests.

Treatment of Data

Following the administration of the pretests, the investigator computed the range, mean, standard deviation, and standard error of the mean for the four groups on the tests for FEV_1, MBC, and SWC_{170}. A one-way analysis of variance was computed to determine if there were any significant differences between the groups on each of the three variables. No significant differences were found; therefore, the groups were considered equated.

At the conclusion of the experimental period, data were again collected and then treated statistically to determine the relationship between participation in a swimming program and changes in pulmonary efficiency and working capacity. The range, mean, standard deviation, and standard error of the mean were again computed for each group on the posttests for FEV_1, MBC, and SWC_{170}. A one-way analysis of variance was computed to determine if there was a significant difference between the groups on the posttest value for the FEV_1, MBC, and SWC_{170} tests. A two-way analysis of variance with repeated measures was computed also to determine if there were significant differences at the .05 level in performance over the trials or the trial means for the four groups.[1] No subsequent test of significance was required for treatment of the data.

Preparation of the Final Written Report

The preparation of the final written report entailed presenting the data in appropriate tables, analyzing and interpreting the data in the tables, summarizing the findings, and drawing conclusions. Final procedures included making recommendations for further studies, compiling a bibliography, and developing an Appendix. Each chapter was written, submitted to the members of the thesis committee for suggestions and/or corrections, and revised in accordance with the recommendations of the committee members.

Summary

In this chapter, the procedures followed in the development of the study were presented under the following

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[1]Allen L. Edwards, Statistical Methods (New York: Holt, Rinehart and Winston, Inc., 1967), p. 293.

center headings: Preliminary Procedures, Selection of the Subjects, Selection and Description of the Instruments, Planning and Conducting the Swimming Program, Collection of Data, Treatment of Data, and Preparation of the Final Written Report.

Procedures followed in the selection of subjects for the study involved notifying parents of known asthmatic children, placing an article in the local newspaper, mailing application forms, and assigning the children at random to the asthmatic experimental group, the non-asthmatic experimental group, the asthmatic control group, and the non-asthmatic control group. The subjects were twenty-eight asthmatic and twenty-eight non-asthmatic boys and girls, aged five through twelve years, who resided in Denton, Texas, during the summer of 1971. The experimental group participated in a swimming program for one hour daily five days a week for four weeks whereas the control group adhered to their daily living activities.

Instruments were selected in accordance with the criteria established. The Collins 13.5 liter Respirometer yielded the data for the evaluation of pulmonary efficiency as measured by the FEV_1 and MBC tests. The instrument used to measure working capacity was the SWC_{170} test on the bicycle ergometer.

The swimming program for the asthmatic and non-asthmatic experimental groups was planned and conducted for four weeks. Data were collected for each subject before and after the experimental period on the tests for FEV_1, MBC, and SWC_{170}. To determine if there were any significant differences between the four groups on the pretests and posttests, a one-way analysis of variance was computed for each of the three tests. To compare the differences in the overall performance of the subjects and to evaluate the changes shown by the subjects, the analysis of variance using a two-factor mixed design with repeated measures on one factor was computed at the .05 level for each of the three tests.

The final written report was prepared by the investigator. Each chapter was presented to the members of the thesis committee for suggestions, and then revisions were made.

In Chapter IV, the analysis of the data will be presented.

CHAPTER IV

PRESENTATION OF THE FINDINGS

In Chapter IV the results of the investigation are presented. The purpose of the study was to determine the relationship between participation in a swimming program and changes in pulmonary efficiency as measured by FEV_1 and MBC and working capacity as measured by SWC_{170}. The experimental group participated five days a week for a period of four weeks in a swimming program whereas the control group adhered to their routine daily living activities.

Description of the Subjects

The subjects utilized in the study were twenty-eight asthmatic and twenty-eight non-asthmatic boys and girls, randomly divided into two experimental and two control groups. Table 1 shows the number of boys and girls comprising each of the four groups, their age, and asthmatic condition. The descriptive data for the ages of the subjects in the four groups are presented in Table 2.

A study of Table 1 shows that the asthmatic control group was comprised of eight boys and six girls, aged five through nine and five through ten respectively. Seven boys and seven girls aged five through twelve were included in the non-asthmatic control group. The asthmatic experimental group was composed of nine boys and five girls, aged five through twelve and five through eleven respectively. Nine boys and five girls, aged five through eight and five through nine respectively, comprised the non-asthmatic experimental group. It should be noted that there were more boys than girls participating in the swimming program. Random assignment and the loss of three girls from the study may possibly account for this result.

TABLE 1

CLASSIFICATION OF SUBJECTS BY AGE, SEX, AND ASTHMATIC CONDITION

Age	Control Groups				Experimental Groups			
	Asth. Boys	Asth. Girls	Non-A. Boys	Non-A. Girls	Asth. Boys	Asth. Girls	Non-A. Boys	Non-A. Girls
5	2	1	1	2	1	2	2	1
6			1		1		1	
7	3	2	1				3	2
8	2	2	1				3	1
9	1		2	2	6			1
10		1		2		2		
11						1		
12			1	1	1			
Total	8	6	7	7	9	5	9	5

TABLE 2

DESCRIPTIVE DATA FOR THE AGES OF THE SUBJECTS IN THE FOUR GROUPS

Group	Range	Mean	Standard Deviation	Standard Error of the Mean
Asthmatic Experimental	5 - 12	9.01	2.41	.64
Non-Asthmatic Experimental	5 - 9	7.16	1.19	.32
Asthmatic Control	5 - 10	7.49	1.59	.43
Non-Asthmatic Control	5 - 12	8.65	2.41	.64

A study of Table 2 reveals that the ages of the subjects comprising the asthmatic experimental and non-asthmatic control groups ranged from five to twelve years, which was a wider range in age than subjects in the asthmatic control group and the non-asthmatic experimental group. The mean ages of the subjects in the asthmatic experimental and non-asthmatic control groups were older than the mean ages of the asthmatic control and non-asthmatic experimental groups. The standard deviations reveal more variability among the subjects of the asthmatic experimental and non-asthmatic control groups than the non-asthmatic experimental and asthmatic control groups. This difference may be attributed to the larger range in age of the subjects in the asthmatic experimental and non-asthmatic control groups.

Following the loss of four subjects as the result of changing vacation plans, moving from Denton, and sickness, the four groups were no longer considered to be equated with respect to age. The findings from the application of analysis of variance are presented in Table 3.

TABLE 3

ANALYSIS OF VARIANCE ON AGES OF SUBJECTS IN THE FOUR GROUPS

Source	Degrees of Freedom	Sum of Squares	Mean Square	F
Between	3	33.640	11.21	2.88*
Within	52	202.280	3.89	
Total	55			

$F_{3,52}$ (.05) = 2.78 *Statistically significant

A study of Table 3 reveals that the use of the analysis of variance to determine if there was a significant difference between the ages of the subjects in the four groups resulted in an F value of 2.88. In order to be significant at the .05 level, with three and fifty-two degrees of freedom, a value of 2.78 had to be obtained. Since the resulting F value was larger than 2.78, it was concluded that the four groups comprising the study were not equated with respect to age.

TABLE 4

RESULTS OF THE DUNCAN'S MULTIPLE-RANGE TEST[1]

	Non-Asthmatic Exp'l 7.16	Asthmatic Control 7.49	Non-Asthmatic Control 8.65	Asthmatic Exp'l 9.01	k	R
7.16		.33	1.49	1.85*	4	1.62
7.49			1.16	1.52	3	1.57
8.65				.36	2	1.49

A study of the results of the Duncan's Multiple-Range Test reveals that a significant difference occurred between the means of the non-asthmatic experimental and asthmatic experimental groups. No significant difference occurred between any other pair of group means.

Personal data of the subjects were collected by a questionnaire to provide information with respect to the causes and severity of their asthmatic attacks. These data appear in the Appendix of this thesis in the following tables: Number of Children in Family, Position in Family, Number of Asthmatic Parents, Number of Asthmatic Brothers and Sisters, Types of Dwelling, Kinds of Pets, Frequency of Attacks, Occurrence of Last Attack, Emergency Medical

[1]James L. Bruning and B. L. Kintz, Computational Handbook of Statistics (Glenview, Illinois: Scott, Foresman and Company, 1968).

Treatment Within the Preceding Year, Causes of Asthmatic Attacks, Season of Asthmatic Attacks, and Type of Weather During Asthmatic Attacks.

A Comparison of the Groups on the Pretests

In order to determine if the four groups were equated with respect to pulmonary efficiency and working capacity, the values yielded by the administration of the pretests for FEV_1, MBC, and SWC_{170} were subjected to statistical treatment. The descriptive data and the resulting F ratios of the one-way analysis of variance for each pretest are shown in Tables 5, 6, 7, and 8.

TABLE 5

DESCRIPTIVE DATA FOR THE FOUR GROUPS ON THE PRETEST FOR FEV_1[a]

Group	Range	Mean	Standard Deviation	Standard Error of the Mean
Asthmatic Experimental	817-2414	1612	517.11	137.90
Non-Asthmatic Experimental	767-1752	1328	277.33	73.95
Asthmatic Control	617-1828	1266	352.13	93.90
Non-Asthmatic Control	857-3031	1637	615.82	164.22

[a]cubic centimeters

A study of Table 5 reveals that the values on FEV_1 ranged from 857 to 3031, 817 to 2414, 617 to 1828, and 767 to 1752 cubic centimeters for the non-asthmatic control, asthmatic experimental, asthmatic control, and non-asthmatic experimental groups respectively. The mean FEV_1 was higher for the non-asthmatic control and asthmatic experimental groups than the mean FEV_1 for the non-asthmatic experimental and asthmatic control groups, which may be attributed to the older subjects in the asthmatic experimental and non-asthmatic control groups. According to Strang,[1] FEV_1 is highly correlated with age. The standard deviations of the non-asthmatic control and asthmatic experimental groups showed more variability than the asthmatic control and non-asthmatic experimental groups, which may be attributed to the wider range in age of subjects in those groups than subjects in the asthmatic control and non-asthmatic experimental groups.

To aid in the interpretation of the values for FEV_1, the investigator sought standardized data for normal children. Comroe,[2] in a study of the timed vital capacity for 1276 boys and 1219 girls aged four through seventeen, found normal FEV_1 values to range from 500 to 4500 cubic centimeters for the boys, and from 350 to 3400 cubic centimeters for the girls. All of the values except 616 cubic centimeters for a boy seven years of age, 372 cubic centimeters

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[1]Strang, "Ventilatory Capacity of Normal Children," 306.

[2]J. H. Comroe, Methods in Medical Research (Chicago: Yearbook Publishers, 1950), p. 361.

for a boy nine years of age, and 1288 cubic centimeters for a boy ten years of age in the present study fell within the range cited by Comroe for each age group.

TABLE 6

DESCRIPTIVE DATA FOR THE FOUR GROUPS ON THE PRETEST FOR MAXIMAL BREATHING CAPACITY[a]

Group	Range	Mean	Standard Deviation	Standard Error of the Mean
Asthmatic Experimental	21-74	46.6	17.68	4.71
Non-Asthmatic Experimental	15-51	35.4	9.45	2.52
Asthmatic Control	18-52	34.5	10.61	2.83
Non-Asthmatic Control	15-70	41.6	16.58	4.42

[a]liters per minute

A study of Table 6 reveals that the values on MBC ranged from 21 to 74 liters per minute and 15 to 70 liters per minute for subjects in the asthmatic experimental and non-asthmatic control groups, and from 18 to 52 liters per minute and 15 to 51 liters per minute for subjects in the asthmatic control and non-asthmatic experimental groups. The mean MBC for subjects in the asthmatic experimental and non-asthmatic control groups were 46.6 and 41.6 liters per minute respectively, and the average MBC for subjects in the asthmatic control and non-asthmatic experimental groups were

34.5 and 35.4 liters per minute respectively. The higher mean MBC for subjects in the asthmatic experimental and non-asthmatic control groups may be a result of the older mean ages of the subjects in the two groups. According to Bernstein,[1] the values for MBC are highly correlated with age. The standard deviations reveal more variability in subjects of the asthmatic experimental and non-asthmatic control groups, which may be attributed to the wider range in age of subjects in those groups than subjects in the asthmatic control and non-asthmatic experimental groups.

To aid in the interpretation of the values for MBC, norms for normal children were sought. In a study conducted by Ferris, Whittenberger, and Gallagher,[2] and a second study conducted by Ferris and Smith,[3] the mean values of MBC for 161 male and 233 female children and adolescents, ages five to seventeen years, are separately presented in tabular form in relation to age. The mean values for MBC ranged from 43 to 155 liters for the males, and 41.2 to 123.1 liters for the females. The values for MBC of both the asthmatic and non-asthmatic groups in the present study were much below the predicted norms. Possibly this finding could be attributed to the fact that Ferris allowed more than three trials in his studies because of the considerable training effect

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[1] Bernstein, "Pulmonary Function in Children," 519.

[2] Ferris, Whittenberger, and Gallagher, "MBC and Vital Capacity in Males."

[3] Ferris and Smith, "MBC and Vital Capacity in Females."

in the MBC. The results recorded by Ferris were the best efforts of the subjects, and further determinations were made if there was a progressive increase. Subjects in the present study were allowed only two trials for the MBC. The subjects in the study cited also exhibited a sense of competition, since they attended opposing schools that were rivals. The subjects in the present study exhibited no sense of competition.

TABLE 7

DESCRIPTIVE DATA FOR THE FOUR GROUPS ON THE PRETEST FOR SWC_{170}[a]

Group	Range	Mean	Standard Deviation	Standard Error of the Mean
Asthmatic Experimental	125-245	180.5	39.46	11.90
Non-Asthmatic Experimental	110-270	157.3	51.88	15.64
Asthmatic Control	120-210	168.1	27.83	8.39
Non-Asthmatic Control	112-250	180.2	49.69	14.98

[a]seconds

A study of Table 7 reveals that the results determined on the SWC_{170} for subjects in the study ranged from 110 to 270 seconds, 112 to 250 seconds, 125 to 245 seconds, and 120 to 210 seconds for the non-asthmatic experimental, non-asthmatic control, asthmatic experimental, and asthmatic control groups respectively. The asthmatic experimental and non-asthmatic control groups had the highest mean SWC_{170}, which would seem to indicate that the subjects with a higher mean age may have a larger range of working capacity than the subjects with a lower mean age. The standard deviations reveal less variability among subjects in the asthmatic control and asthmatic experimental groups than among the subjects in the two non-asthmatic groups.

To aid in the interpretation of the values for SWC_{170}, norms were sought by the investigator, but none were found. It is interesting to note, however, that the mean SWC_{170} of subjects in the asthmatic experimental group was higher than the mean SWC_{170} for subjects in the two non-asthmatic groups. This finding probably can be attributed to the higher mean age of the subjects in the asthmatic experimental group. A study of 243 boys and girls, aged six through fourteen years, by Adams, Linde, and Miyake[1] revealed that the working capacity was highly correlated with age, although the exact technique was not the same as that used in the present study.

Table 8 shows the results of three one-way analysis of variance measures for each pretest. The large mean squares within of 30249997.82 cubic centimeters for FEV_1, 197.38 liters for MBC, and 1873.24 seconds for SWC_{170} show much variability of values within the subjects of the study.

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[1]Forrest H. Adams, Leonard M. Linde, and Hisazumi Miyake, "The Physical Working Capacity of Normal School Children," Pediatrics, XXVIII (July, 1961), 55-64.

The smaller mean squares between of 510363.56 cubic centimeters for FEV_1 and 1355.18 seconds for SWC_{170} reveal that the mean scores of the four groups were close together. The resulting F ratios of .02 for FEV_1, 2.29 for MBC, and .72 for SWC_{170} were not significant at the .05 level; therefore, the four groups were considered to be equated with respect to FEV_1, MBC, and SWC_{170} on the pretests.

TABLE 8

ANALYSIS OF VARIANCE FOR THE FOUR GROUPS ON THE PRETESTS FOR FEV_1, MBC, and SWC_{170}

Test	Source	Degrees of Freedom	Sum of Squares	Mean Square	F
FEV_1	Between	3	1531090.69	510363.56	.02
	Within	52	1572999886.71	30249997.82	
	Total	55			
MBC	Between	3	1356.33	452.11	2.29
	Within	52	10263.60	197.38	
	Total	55			
SWC_{170}	Between	3	4065.55	1355.18	.72
	Within	40	74929.50	1873.24	
	Total	43			

$F_{3,52}$ (.05) = 2.79

$F_{3,40}$ (.05) = 2.84

A Comparison of the Groups on the Posttests

To determine the relationship between participation in a swimming program and changes in pulmonary efficiency and working capacity, the scores yielded by the subjects on the posttests were subjected to statistical treatment. The descriptive data and resulting F ratios for the one-way analysis of variance for each posttest are shown in Tables 9, 10, 11, and 12.

TABLE 9

DESCRIPTIVE DATA FOR THE FOUR GROUPS ON THE POSTTEST FOR FEV_1[a]

Group	Range	Mean	Standard Deviation	Standard Error of the Mean
Asthmatic Experimental	372-2494	1512	580.13	154.70
Non-Asthmatic Experimental	523-1724	1280	332.73	88.73
Asthmatic Control	631-1954	1296	343.86	91.70
Non-Asthmatic Control	862-2909	1599	595.80	158.88

[a]cubic centimeters

A study of Table 9 reveals that the values on FEV_1 for the subjects in the study ranged from 862 to 2909 cubic centimeters, 372 to 2494 cubic centimeters, 631 to 1954 cubic centimeters, and 523 to 1724 cubic centimeters for the non-asthmatic control, asthmatic experimental, asthmatic control, and non-asthmatic experimental groups respectively. The highest mean values for FEV_1 were yielded by subjects in the non-asthmatic control and asthmatic experimental groups, which may again be attributed to the older subjects in those groups. The standard deviations reveal that subjects in the non-asthmatic control and asthmatic experimental groups showed more variability than subjects in the remaining groups. This variability may be attributed to the greater range in age of subjects in the non-asthmatic control and asthmatic experimental groups. A comparison of the values for FEV_1 in the present study with Comroe's predicted values obtained from 1276 boys and 1219 girls, aged four to seventeen, indicated that five values yielded by asthmatic subjects were below the norms, as was the observation also with the pretest values. Changes were noted, however, between pretest and posttest values for FEV_1. A lower mean FEV_1 was noted for subjects in the experimental groups. Subjects in the asthmatic control group showed improvements in posttest values for FEV_1.

TABLE 10

DESCRIPTIVE DATA FOR THE FOUR GROUPS ON THE POSTTEST FOR MAXIMAL BREATHING CAPACITY[a]

Group	Range	Mean	Standard Deviation	Standard Error of the Mean
Asthmatic Experimental	14-85	45.3	20.98	5.59
Non-Asthmatic Experimental	21-58	39.0	10.78	2.87
Asthmatic Control	21-60	35.4	12.45	3.32
Non-Asthmatic Control	21-83	45.2	20.03	5.34

[a]liters per minute

A study of Table 10 reveals that the values on MBC for the subjects in the study ranged from 14 to 85 liters, 21 to 83 liters, 21 to 60 liters, and 21 to 58 liters for the asthmatic experimental, non-asthmatic control, asthmatic control, and non-asthmatic experimental groups respectively. The mean MBC for subjects in the asthmatic experimental and non-asthmatic control groups were similar to each other, and higher than the mean MBC for subjects in the asthmatic control and non-asthmatic experimental groups. The standard deviations reveal that subjects in the asthmatic experimental and non-asthmatic control groups showed more variability than subjects in the asthmatic control and non-asthmatic experimental groups. This variability may be attributed to the greater range in age of subjects in the non-asthmatic control and asthmatic experimental groups. A comparison of the data yielded in the present study with the norms for 161 boys and 233 girls, aged five through seventeen, presented by Ferris, indicated that the values for MBC were still much below the predicted ones, as was the result also with the pretest values. Improvements were noted, however, in posttest values for MBC of subjects in the two control groups and the non-asthmatic experimental group.

A study of Table 11 reveals that the values determined on the SWC_{170} for the subjects in the study ranged from 115 to 280 seconds, 125 to 260 seconds, 90 to 248 seconds, and 110 to 190 seconds for subjects in the non-asthmatic experimental, asthmatic experimental, non-asthmatic control, and asthmatic control groups respectively. The mean SWC_{170} for subjects in the asthmatic experimental and non-asthmatic control groups were higher than the mean SWC_{170} for subjects in the non-asthmatic experimental and asthmatic control groups, which may again be attributed to the higher mean age of subjects in the asthmatic experimental and non-asthmatic control groups. The standard deviation for subjects in the asthmatic control group was much below the standard deviations of subjects in the other three groups. This lesser variability may again be attributed to a possible smaller working capacity in asthmatic subjects than non-asthmatic subjects.

TABLE 11

DESCRIPTIVE DATA FOR THE FOUR GROUPS ON THE POSTTEST FOR SWC_{170}[a]

Group	Range	Mean	Standard Deviation	Standard Error of the Mean
Asthmatic Experimental	125-260	189.6	47.35	14.27
Non-Asthmatic Experimental	115-280	167.7	53.21	16.04
Asthmatic Control	110-190	163.2	29.35	8.85
Non-Asthmatic Control	90-248	174.0	52.09	15.70

[a]seconds

It is interesting to note that the subjects in the asthmatic experimental group had values for SWC_{170} that were considerably higher than the values for subjects in the other three groups. This finding may be attributed possibly to the higher mean age of the subjects in the asthmatic experimental group. Improvements were noted in posttest values for SWC_{170} of subjects comprising the two experimental groups, but the changes were not significant. Subjects in the control groups showed a decrease in posttest values for SWC_{170}.

TABLE 12

ANALYSIS OF VARIANCE FOR THE FOUR GROUPS ON THE POSTTESTS FOR FEV_1, MBC, AND SWC_{170}

Test	Source	Degrees of Freedom	Sum of Squares	Mean Square	F
FEV_1	Between	3	1055409.77	351803.26	1.53
	Within	52	11966561.07	230126.17	
	Total	55			
MBC	Between	3	1009.48	336.49	1.21
	Within	52	14471.36	278.30	
	Total	55			
SWC_{170}	Between	3	4371.18	1457.06	.67
	Within	40	86495.46	2162.39	
	Total	43			

$F_{3,52}$ (.05) = 2.79

$F_{3,40}$ (.05) = 2.84

Table 12 shows the mean squares between, the mean squares within, and the resulting F ratios for each posttest. The large mean square within for FEV_1 showed much variability within the subjects of the study. The mean square between revealed that the means of the groups exhibited a wide distribution. An F ratio of 2.79, with three and fifty-two degrees of freedom, was required for significance at the .05 level. The resulting F ratio of 1.53 was not significant, indicating that there were no significant differences between the four groups on the values of the posttest for FEV_1.

The mean square within for MBC showed considerable variability within the subjects. The mean square between revealed that the mean values of the groups for MBC exhibited a wide distribution. The resulting F ratio of 1.21 was not significant; therefore, the difference between the four groups on the values of the posttests for MBC was not significant.

The mean square within for SWC_{170} showed variability within the subjects. The smaller mean square between revealed that the mean values of the groups for SWC_{170} were close together. An F ratio of 2.84, with three and forty degrees of freedom, was required for significance at the .05 level. The resulting F ratio of .67 was not significant, indicating that there were no significant differences between the four groups on the values of the posttest for SWC_{170}.

A Comparison of the Pretest and Posttest for the Four Groups

Although there were no significant differences between the values for FEV_1, MBC, and SWC_{170} on the posttests for the subjects in the four groups, a two-way analysis of variance with repeated measures was computed to determine if there was a significant difference between the pretests and posttests and/or the four groups with respect to pulmonary efficiency and working capacity. The resulting F ratios are shown in Tables 13, 14, and 15 for FEV_1, MBC, and SWC_{170} respectively.

TABLE 13

ANALYSIS OF VARIANCE WITH REPEATED MEASURES FOR THE FOUR GROUPS FOR FEV_1

Source	Degrees of Freedom	Sum of Squares	Mean Square	F
A Between All Subjects	55	24724533.78		
AxB Between Groups	3	2526366.96	842122.32	1.97
C Between Subjects Same Group	52	22198166.82	426887.82	
B Within All Subjects	56	888926.50		
Between Trials	1	42160.08	42160.08	2.79*
Groups X Trials	3	60133.45	20044.49	1.33
Subjects/Groups X Trials	52	786632.96	15127.56	
Total	111	25613460.23		

$F_{3,52}$ (.05) = 2.79 *Statistically Significant

Table 13 shows a summary of the two-way analysis of variance with repeated measures for the four groups on FEV_1.

An F ratio of 2.79, with three and fifty-two degrees of freedom, was required for significance at the .05 level. The F ratio for the groups by trials, 1.33, is not significant; therefore, the interaction of the groups and the two trials had no effect upon the FEV_1 of the subjects. This finding may be attributed to the small difference between group trials. The F ratio between groups is also not significant. The F ratio between trials is significant, however, which indicates that there is a difference between the two trials. Possibly this result may be attributed to the familiarity of the subjects with the equipment and methods used to measure pulmonary efficiency and with the investigator.

TABLE 14

ANALYSIS OF VARIANCE WITH REPEATED MEASURES FOR THE FOUR GROUPS FOR MAXIMAL BREATHING CAPACITY

Source	Degrees of Freedom	Sum of Squares	Mean Square	F
Between All Subjects	55	25515.49		
Between Groups	3	2246.38	748.80	1.67
Between Subjects Same Group	52	23269.11	447.48	
Within All Subjects	56	1662.50		
Between Trials	1	77.22	77.22	2.74
Groups X Trials	3	119.46	39.82	1.41
Subjects/Groups X Trials	52	1465.82	28.19	
Total	111	27177.99		

$F_{3,52}$ (.05) = 2.79

A study of Table 14 reveals that the resulting F ratios of groups by trials and between groups for MBC are not significant. This finding may be attributed to the small degree of difference between groups and the insignificant difference between the pretest and posttest of each group for the three tests. The F ratio between trials of 2.74 approaches significance, which may suggest a possible learning effect or other factors which may not be accounted for at this time.

TABLE 15

ANALYSIS OF VARIANCE WITH REPEATED MEASURES FOR THE FOUR GROUPS FOR SWC_{170}

Source	Degrees of Freedom	Sum of Squares	Mean Square	F
Between All Subjects	43	158813.82		
Between Groups	3	7128.27	2376.09	.63
Between Subjects Same Group	40	151685.55	3792.14	
Within All Subjects	44	11144.00		
Between Trials	1	96.18	96.18	.40
Groups X Trials	3	1308.45	436.15	1.79
Subjects/Groups X Trials	40	9739.36	243.48	
Total	87	169957.82		

$F_{3,40}$ (.05) = 2.84

Table 15 reveals the results of the two-way analysis of variance with repeated measures for the four groups on SWC_{170}. An F ratio of 2.84, with three and forty degrees of freedom, was required for significance at the .05 level. The F ratio for the groups by trial, 1.79, is not significant. This finding may be attributed to the small difference between the group values for SWC_{170} for the two trials. The resulting F ratio of .63 for between groups was not significant, indicating that the amount of natural variability may have been too great to result in differences between the four groups. The F ratio of .40 between trials is also not significant. This result may be attributed to the lack of a learning effect for SWC_{170}.

Summary

In this chapter the results of the investigation to determine the relationship between participation in a swimming program and changes in pulmonary efficiency as measured by FEV_1 and MBC and working capacity as measured by SWC_{170} were presented. The experimental group participated five days a week for a period of four weeks in a swimming program whereas the control group adhered to their daily living activities.

The subjects in the study were fifty-six asthmatic and non-asthmatic boys and girls. The asthmatic experimental group was comprised of nine asthmatic boys and five asthmatic girls, with a mean age of 9.01 years. The non-asthmatic experimental group was comprised of nine non-asthmatic boys and five non-asthmatic girls, with a mean age of 7.16 years. The asthmatic control group was comprised of eight asthmatic boys and six asthmatic girls, with a mean age of 7.49 years. The non-asthmatic control group was comprised of seven non-asthmatic boys and seven non-asthmatic girls, with a mean age of 8.65 years.

The values of the subjects on the pretests were subjected to statistical treatment to determine whether the groups were equated with respect to FEV_1, MBC, and SWC_{170}. The resulting F ratios of .017 for FEV_1, 2.29 for MBC, and .723 for SWC_{170} indicated that the four groups did not differ significantly prior to the beginning of the experimental period with respect to FEV_1, MBC, and SWC_{170}. An F ratio of 2.79, with three and fifty-five degrees of freedom, and an F ratio of 2.84, with three and forty degrees of freedom, were required for significance at the .05 level. It was noted, however, that the mean values for the asthmatic experimental and non-asthmatic control groups were greater than those of the non-asthmatic experimental and asthmatic control groups on all three pretests. Possibly this finding may be attributed to the greater mean age of the subjects in the asthmatic experimental and non-asthmatic control groups.

A comparison of the values of the subjects on the posttests revealed an F ratio of 1.53 for FEV_1, 1.21 for MBC, and .67 for SWC_{170}. These F ratios were not significant, which indicated that the four groups did not differ significantly at the conclusion of the study. It was noted that the mean values for the asthmatic experimental and non-asthmatic control groups were again greater than those of the non-asthmatic experimental and asthmatic control groups. The range of values and large standard deviations for each of the pretests and posttests may be explained by the wide range in ages and the familiarity of the subjects with the equipment and the investigator.

A further comparison of the values of the four groups on the pretests and posttests by analysis of variance, using a two-factor mixed design with repeated measures on one factor, resulted in a significant F ratio between trials of FEV_1, and an F ratio between trials of MBC that approached significance. This finding may possibly be attributed to a learning effect.

A summary and discussion of the study, a conclusion based upon the findings, and recommendations for further studies are presented in Chapter V.

CHAPTER V

SUMMARY, CONCLUSION, AND RECOMMENDATIONS FOR FURTHER STUDIES

Summary

The prevalence of asthma in the United States necessitates more research concerning the value of exercise in the treatment and rehabilitation of asthmatic patients. Numerous programs of physical conditioning have developed in an attempt to aid the person with asthma, but no statistically significant differences have resulted from such programs.

The present investigation entailed a study of the relationship between participation in a swimming program and the changes in pulmonary efficiency and working capacity as revealed by pretest and posttest values for FEV_1, MBC, and SWC_{170}. The subjects utilized in the study were fifty-six asthmatic and non-asthmatic boys and girls, ages five through twelve years, who were residing in Denton, Texas, during the summer of 1971. The asthmatic subjects were randomly assigned to one of two groups, and the non-asthmatic subjects were randomly assigned to one of two groups. The groups were assigned as experimental or control by random selection. The experimental groups participated five days a week for a period of four weeks in a swimming program whereas the control groups adhered to their routine daily living activities.

Data were collected individually on the tests for FEV_1, MBC, and SWC_{170} before and after the experimental period for each asthmatic and non-asthmatic subject. A one-way analysis of variance was computed for each of the three tests to determine if there were any significant differences at the .05 level between the four groups on the values for the pretests and the values for the posttests. A two-way analysis of variance with repeated measures was computed for each of the three tests to determine if there were any significant differences between the four groups' performance over the pretests and posttests.

The statistical treatment of the data revealed the following findings:

1. A comparison of the values for the subjects in the four groups on the posttests by a one-way analysis of variance revealed that:

   a. There was no significant difference between the groups with respect to the values on the FEV_1 test.

   b. There was no significant difference between the groups with respect to the values on the MBC test.

   c. There was no significant difference between the groups with respect to the values on the SWC_{170} test.

Based upon these findings, the investigator failed to reject the hypotheses of the study which were: There is no difference between the asthmatic control group, asthmatic experimental group, non-asthmatic control group, and non-asthmatic experimental group after the experimental period with respect to pulmonary efficiency as measured by forced expiratory volume for one second and maximal breathing capacity, and working capacity as determined by the Submaximal Working Capacity-170 Test.

2. A comparison of the pretest and posttest values for the subjects comprising the four groups by a two-way analysis of variance with repeated measures revealed that:

a. There was a significant difference between the values on the pretests and posttests with respect to FEV_1.

b. There was no significant difference between the values on the pretests and posttests with respect to MBC.

c. There was no significant difference between the values on the pretests and posttests with respect to SWC_{170}.

Conclusion

It was concluded from the findings of the present study that participation of asthmatic and non-asthmatic children in a swimming program for a period of one month did not contribute to a significant increase in pulmonary efficiency as measured by FEV_1 and MBC, nor significantly change working capacity as estimated by SWC_{170}. There was, however, a significant difference between the pretest and posttest for FEV_1 of all subjects. This improvement was attributed to a possible learning effect. The posttests for MBC and SWC_{170} revealed changes for subjects in the four groups, but the differences were not statistically significant. The findings of this study were limited by the number of asthmatic and non-asthmatic children in Denton, Texas, who participated in the study; by the tests selected to measure pulmonary efficiency and working capacity; by the asthmatic conditions of the children during the tests; and by the absence of criteria for determining the degree of asthma in the subjects.

The investigator and her assistants believed that the asthmatic and non-asthmatic children benefited from their participation in the swimming program in many ways which were not measurable. Several of the children appeared to show more self-confidence, less fear of water, and an improvement in the ability to get along with others. The parents reported that the utilization of the breathing exercises by their asthmatic children was of value in lessening the frequency and severity of asthmatic attacks.

Recommendations for Further Studies

After conducting the swimming program and analyzing the results of the present study, the investigator recommends that the following studies be undertaken.

1. An experimental study similar to the present one, using pre-school children as subjects.

2. An experimental study similar to the present one, using asthmatic adults as subjects.

3. An experimental study similar to the present one, conducted during the school year with sessions two or three times a week.

4. An experimental study similar to the present one, using a combination of a swimming program and a physical conditioning program as the independent variable.

5. A study similar to the present one with a longer and/or more physically demanding experimental period.

6. An experimental study of swimming for asthmatic and non-asthmatic children with a delayed posttest to determine the lasting benefits of the program.

7. A study of the relationship between participation in a swimming program and changes in psychological traits of asthmatic and non-asthmatic children.

A P P E N D I X E S

APPENDIX A

Letter to Parents and Application Blank

Doctor's Permission Form

Questionnaire for Parents

TEXAS WOMAN'S UNIVERSITY

DENTON, TEXAS 76204

COLLEGE OF HEALTH,
PHYSICAL EDUCATION, AND RECREATION

May 21, 1971

Dear Parent:

A free swimming program for asthmatic and "non-asthmatic" children between the ages of five and twelve will be conducted at T.W.U. from June 14 through July 9, 1971. If you are interested in this program, please fill out the form below and return it to me before June 2, 1971. My address is: Miss Elsa Claverie, 1717 N. Locust, Apt. 4, Denton, Texas, 76201. I will then contact you by phone to give you more detailed information.

Thank you very much.

Sincerely,

Elsa Claverie

Student's Name ______________________________

Age ____________ Male ____________ Female ____________

Student's Doctor ______________________________

Student's Swimming Ability ______________________________

Is the child allergic to chlorine? ______________________________

Is transportation needed? ______________________________

Parent's Name ______________________________

Address ______________________________

Phone number ____________________

Names of friends who may be interested and/or other asthmatic children:

Swimming Program for Asthmatic Children

June 14 - July 9, 1971

Texas Woman's University

Denton, Texas

I have examined ______________________________

It is my opinion that he is physically able to participate in swimming activities except as noted below:

Examining Physician ___________________________

Address ______________________________________

Telephone _______________ Date _______________

Questionnaire Form

Child's Name ____
Last First Middle

Sex ______________ Race ____________ Age __________

Date of Birth ________________________
Month Day Year

Parent or Guardian ___________________________________

Address ____

Telephone ___________________

BACKGROUND OF FAMILY

Father's Name ____

Address _____________________ Occupation _____________

Asthmatic? __________________ If yes, what age was the first occurrence? ________________ Do you still have asthmatic attacks? ________________ How frequently? _______________

Mother's Name ____

Address _____________________ Occupation _____________

Asthmatic? __________________ If yes, what age was the first occurrence? ________________ Do you still have asthmatic attacks? ________________ How frequently? _______________

How many children are in the family? _______ Boys _______ Girls _____

List the Name of each child	Sex	Age	Does child have asthma?	At what age was first attack?

What pets do you have? (Please circle)

None Dog Cat Bird Fish Gerbil

Other ____

In what type of dwelling does the child reside? ______________

BACKGROUND OF THE CHILD

Is the child asthmatic? ____________________

Questions 1. - 8. are for Asthmatic Children ONLY!

1. At what age was the first occurrence of asthma? (Circle one)

   Since birth   6 months   1 year   2 years   3 years
   4 years   5 years

2. How frequently do attacks occur? Every day   3 times a week

   Once a week   Twice a month   Once a month
   Once in two months   Once in 3 months

3. When was the child's last attack? Yesterday   Last week

   Last month   2 months ago   3 months ago   6 months ago

4. What seems to cause asthmatic attacks? Dust   Pollen   Fur

   Feathers   Grass   Flowers   Fatigue   Infection   Changes in weather   Other ____________________

5. In what season of the year is the condition most severe?

   Summer   Fall   Winter   Spring

6. What weather conditions produce the most complications?

   Cold   Hot   Humid   Rainy   Windy   Dusty   No difference

7. How many times in the last year has the child's condition been severe enough to require emergency medical treatment?

   One   Two   Three   Four   Five   Six   More than six

8. What type of treatment did he require? ____________________

FOR ALL CHILDREN:

Does the child have any other medical problems? ________________

What are the child's three favorite recreational activities?

What precautions should be taken with your child?

Parent may be reached: Telephone __________ Telephone __________

I am giving permission for my child to participate in the swimming program and to perform the tests for pulmonary efficiency and physical working capacity that will be administered.

____
Parents' Signature

Please bring this form and the medical form when you bring your child to T.W.U. for the tests. Thank you very much. I am looking forward to meeting you.

Sincerely,

Elsa Claverie

APPENDIX B

Newspaper Article

On May 31, 1971, the following article was placed in the Denton Record-Chronicle newspaper in Denton, Texas.

Does Swimming Improve Breathing?

TWU Grad Student To Test Theory In Summer Classes

Elsa Claverie, Texas Woman's University graduate student, will take to the water for her thesis.

To support her thesis that children will improve their breathing capacity due to swimming exercises, Miss Claverie will conduct a swimming program for asthmatic and non-asthmatic children between the ages of 5 and 12.

The program is set for June 14 through July 9 at the TWU indoor pool. Classes will meet from 3 to 4 p.m. Monday through Friday.

Fifteen asthmatic children and five non-asthmatic children have already registered. Miss Claverie would like to have an enrollment of 60, she said.

As partial fulfillment for her master's degree, she will conduct the program under the guidance of Dr. Claudine Sherrill, Dr. Joel Rosentswieg and Marjorie Keele, M.D.

Miss Claverie has had 10 years experience as a swimming instructor.

Using a Collins respirometer purchased last year by the university for a similar program, Miss Claverie will have her pupils breathe into the machine before the instruction begins and at completion of the program.

The children take a deep breath and blow into a tube on the machine as long and hard as possible. A drum floating in water is lifted up by the breathing. A pen sticking out of the drum records its movement on paper attached to a kymograph, which revolves while the drum is moved up and down.

During the four-week program, the children will perform breathing exercises, play water games and receive swimming instruction.

Miss Claverie will conduct classes for beginning and advanced swimmers.

Parents of children who participated in the similar program last summer reported that their children had fewer asthmatic attacks during the year, even though the results may not have shown on the respirometer, Miss Claverie stated.

She suggested that parents who may be interested in this program should call the TWU Health and Physical Education department.

APPENDIX C

Tables 16 - 28

Derived from Parents' Questionnaire

TABLE 16

AGES AT OCCURRENCE OF FIRST ASTHMATIC ATTACK

Group	Birth	3 mos.	6 mos.	1 yr.	2 yrs.	3 yrs.	4 yrs.
Asthmatic Experimental	2	1	1	4	1	1	4
Asthmatic Control	2	1	1	3	3	1	3

TABLE 17

NUMBER OF CHILDREN IN FAMILY

Group	One	Two	Three	Four	Five
Asthmatic Experimental		4	4	5	1
Non-Asthmatic Experimental	1	1	9	2	1
Asthmatic Control	1	4	7	2	
Non-Asthmatic Control	1	3	8	2	

TABLE 18

FREQUENCY OF ATTACKS

Group	Every day	Once a week	Twice a month	Once a month	Once in 2 months	Once in 3 months
Asthmatic Experimental	2	1	2	2	1	6
Asthmatic Control	3	1	2	1	1	6

TABLE 19

OCCURRENCE OF LAST ATTACK

Group	Yesterday	Last Week	Last Month	2 mos.	3 mos.	6 mos.
Asthmatic Experimental	1	2	2	5	3	1
Asthmatic Control	2	2	3	3	1	3

TABLE 20

EMERGENCY MEDICAL TREATMENT WITHIN THE PRECEDING YEAR

Group	None	Adrenaline	Oxygen	Cortisone	Other Drugs
Asthmatic Experimental	6	2	2	3	3
Asthmatic Control	3	5	1	2	3

TABLE 21

CAUSES OF ASTHMATIC ATTACKS

Group	Dust	Pollen	Fur	Changes in Weather	Grass	Fatigue	Infec-tion	Feathers
Asthmatic Experimental	10	10	5	9	6	4	6	3
Asthmatic Control	7	7	3	9	4	2	8	2

TABLE 22

NUMBER OF ASTHMATIC PARENTS

Group	0	1	2
Asthmatic Experimental	14		
Non-Asthmatic Experimental	12	2	
Asthmatic Control	10	3	1
Non-Asthmatic Control	12	2	

TABLE 23

NUMBER OF ASTHMATIC BROTHERS AND SISTERS

Group	0	1	2
Asthmatic Experimental	8	5	1
Non-Asthmatic Experimental	11	3	
Asthmatic Control	9	5	
Non-Asthmatic Control	10	4	

TABLE 24

POSITION IN FAMILY

Group	Youngest	Middle	Oldest
Asthmatic Experimental	4	5	5
Non-Asthmatic Experimental	2	7	5
Asthmatic Control	5	5	4
Non-Asthmatic Control	4	6	4

TABLE 25

TYPES OF DWELLING

Group	Brick House	Frame House	Apartment
Asthmatic Experimental	8	6	
Non-Asthmatic Experimental	8	6	
Asthmatic Control	7	6	1
Non-Asthmatic Control	9	5	

TABLE 26

KINDS OF PETS

Group	None	Dog	Cat	Bird	Fish	Horse	Gerbil	Turtle
Asthmatic Experimental	2	11	3		6	1	1	
Non-Asthmatic Experimental	1	10	5		1	3		1
Asthmatic Control	2	6	2		3	2	1	1
Non-Asthmatic Control		10	2	1	1	5		

TABLE 27

SEASON OF ASTHMATIC ATTACKS

Group	Summer	Fall	Winter	Spring
Asthmatic Experimental		12	7	5
Asthmatic Control		6	9	7

TABLE 28

TYPE OF WEATHER DURING ASTHMATIC ATTACKS

Group	Cold	Hot	Humid	Rainy	Windy	Dusty	No Difference
Asthmatic Experimental	2		3	3	10	11	
Asthmatic Control	4	1	4	5	5	6	1

APPENDIX D

Table 29

Height and Weight of Subjects in Study

TABLE 29

HEIGHT AND WEIGHT OF SUBJECTS IN STUDY

Subject	Height in inches	Weight in pounds
E - 1[a]	45¼	47½
E - 2	45½	50
E - 3	44	48
E - 4	44 3/4	40½
E - 5	57	75
E - 6	56	80½
E - 7	50	54
E - 8	54½	61
E - 9	52¼	53
E -10	51	57
E -11	54	65
E -12	56	101
E -13	61½	104
E -14	59	130
E -15[b]	43	40½
E -16	43	43½
E -17	44¼	44½
E -18	49 3/4	59
E -19	49	59½
E -20	43	39

TABLE 29--Continued

Subject	Height in inches	Weight in pounds
E -21	47	45
E -22	51½	69½
E -23	50	59
E -24	48	50
E -25	53	66
E -26	48½	53
E -27	51	60
E -28	54½	65
C - 1[c]	44	40
C - 2	44	38
C - 3	44	46
C - 4	47 3/4	58
C - 5	46½	47
C - 6	48	50
C - 7	48	47½
C - 8	49½	52
C - 9	55	106
C -10	51½	84
C -11	47½	52
C -12	49 3/4	50

TABLE 29--Continued

Subject	Height in inches	Weight in pounds
C -13	53	64½
C -14	52	64
C -15[d]	43½	46
C -16	42½	38
C -17	41¼	37
C -18	46	48½
C -19	46½	53
C -20	50½	55
C -21	57	74
C -22	50½	58
C -23	56½	87
C -24	55	73½
C -25	52	76
C -26	57	97
C -27	63	100
C -28	60½	100½

[a]asthmatic experimental group

[b]non-asthmatic experimental group

[c]asthmatic control group

[d]non-asthmatic control group

APPENDIX E

Daily Lesson Plans for Subjects Aged 6-12 Years

DAILY LESSON PLANS

At the beginning of the experimental period, the investigator and her assistants found it necessary to conduct a separate swimming period for the subjects in the experimental group who were five years of age. The daily lesson plans for the subjects five years old appear on pages 135 through 141 in the Appendix.

The subjects in the experimental group aged six through twelve years participated in the swimming program for one hour five days a week, for a period of four weeks. The daily lesson plans for the beginning (shown as A below) and intermediate (shown as B below) swimmers appear below, and a description of the games appears on page 145 through 147 in the Appendix.

Monday, June 14, 1971 3-4 P.M.

1. Demonstration and practice of abdominal breathing exercises for two minutes in supine position.
2. Swimming test for all subjects to determine ability.
3. Swimming instructions for thirty minutes, including:
   - A. Three bobs in shallow water
   - B. Ten bobs in deep water
4. Games for fifteen minutes
   - A. Walking race and London Bridge
   - B. Relay races

Tuesday, June 15, 1971 3-4 P.M.

1. Breathing exercises for two and one-half minutes in supine position.
2. Swimming instructions for forty-five minutes, including:
   A. Five bobs in shallow water
   B. Fifteen bobs in deep water
3. Ping-Pong Puff Relays for twelve minutes
   A. Walking in shallow water
   B. Swimming in deep water

Wednesday, June 16, 1971 3-4 P.M.

1. Breathing exercises for three minutes in supine position.
2. Swimming instructions for forty-five minutes, including:
   A. Seven bobs in shallow water
   B. Twenty bobs in deep water
3. Relay races for twelve minutes
   A. Walking races in shallow water
   B. Swimming races in deep water

Thursday, June 17, 1971 3-4 P.M.

1. Breathing exercises for three and one-half minutes.
2. Swimming instructions for forty-five minutes, including:
   A. Ten bobs in shallow water
   B. Twenty-five bobs in deep water

3. Flutter-By relay and Ping-Pong-Puff relays for twelve minutes.

Friday, June 18, 1971 3-4 P.M.

1. Breathing exercises for four minutes in supine position.
2. Swimming instructions for forty minutes, including:
   A. Twelve bobs in shallow water
   B. Thirty bobs in deep water
3. Beach ball games in shallow water and deep water for sixteen minutes.
   A. Blow-Up in shallow water
   B. Keep Away in deep water

Monday, June 21, 1971 3-4 P.M.

1. Breathing exercises for four and one-half minutes in supine position.
2. Swimming instructions for forty-five minutes, including:
   A. Fifteen bobs in shallow water
   B. Thirty-five bobs in deep water
3. Games and safety rules for ten minutes
   A. Flutter-By and Go 'Round and 'Round the Village in shallow water
   B. Smallcraft safety in deep water

Wednesday, June 23, 1971 3-4 P.M.

1. Breathing exercises for five and one-half minutes in supine position.

2. Swimming instructions for forty-five minutes, including:
   A. Twenty bobs in shallow water
   B. Forty-five bobs in deep water
3. Games for ten minutes
   A. Balloon Blow-Up and relays in shallow water
   B. Volleyball in the deep water

Thursday, June 24, 1971   3-4 P.M.

1. Breathing exercises for six minutes in supine position.
2. Swimming instructions for forty-five minutes, including:
   A. Twenty-two bobs in shallow water
   B. Fifty bobs in deep water
3. Games and relays for nine minutes.
   A. Ping-Pong-Puff in shallow water
   B. Marco Polo in deep water

Friday, June 25, 1971   3-4 P.M.

1. Breathing exercises for two minutes in a sitting position.
2. Swimming instructions for forty-five minutes, including:
   A. Twenty-five bobs in shallow water
   B. Fifty-five bobs in deep water

3. Relay races for twelve minutes
   A. Blow-Up and balloon races in shallow water
   B. Swimming races in deep water

Monday, June 28, 1971 3-4 P.M.

1. Breathing exercises for two and one-half minutes in a sitting position.
2. Swimming instructions for forty-five minutes, including:
   A. Twenty-eight bobs in shallow water
   B. Sixty bobs in deep water
3. Flutter-By relays in shallow and deep water for twelve minutes.

Tuesday, June 29, 1971 3-4 P.M.

1. Breathing exercises for three minutes in a sitting position.
2. Swimming instructions for forty-five minutes, including:
   A. Thirty bobs in shallow water
   B. Sixty-five bobs in deep water
3. Games and relay races for twelve minutes
   A. London Bridge and Go 'Round and 'Round the Village in shallow water.
   B. Swimming races in deep water

Wednesday, June 30, 1971 3-4 P.M.

1. Breathing exercises for three and one-half minutes in a sitting position.
2. Swimming instructions for forty-five minutes, including:
   A. Thirty-three bobs in shallow water
   B. Seventy bobs in deep water
3. Safety and rescue skills for beginning and intermediate swimmers for twelve minutes.

Thursday, July 1, 1971 3-4 P.M.

1. Breathing exercises for four minutes in a sitting position.
2. Swimming instructions for forty-five minutes, including:
   A. Thirty-five bobs in shallow water
   B. Seventy-five bobs in deep water
3. Relay races for ten minutes
   A. Walking races and Flutter-By in shallow water
   B. Swimming races in deep water

Friday, July 2, 1971 3-4 P.M.

1. Breathing exercises for two minutes in a standing position.
2. Swimming instructions for forty-five minutes, including:
   A. Thirty-eight bobs in shallow water
   B. Eighty bobs in deep water

3. Rescue skills and relays for twelve minutes
    A. Instruction and practice in mouth-to-mouth resuscitation for beginning swimmers
    B. Swimming races in deep water

Monday, July 5, 1971   3-4 P.M.

1. Breathing exercises for two and one-half minutes in a standing position.
2. Swimming instructions for forty-five minutes, including:
    A. Forty bobs in shallow water
    B. Eighty-five bobs in deep water
3. Relay races for twelve minutes
    A. Relay races with balls in shallow water
    B. Swimming races in deep water

Tuesday, July 6, 1971   3-4 P.M.

1. Breathing exercises for three minutes in a standing position.
2. Swimming instructions for forty-five minutes, including:
    A. Forty-two bobs in shallow water
    B. Ninety bobs in deep water
3. Games and relays for twelve minutes
    A. London Bridge and Go 'Round and 'Round the Village in shallow water
    B. Swimming relay races in deep water

Wednesday, July 7, 1971 3-4 P.M.

1. Breathing exercises for three and one-half minutes in a standing position.
2. Swimming instructions for forty-five minutes, including:
   A. Forty-five bobs in shallow water
   B. Ninety-five bobs in deep water
3. Flutter-By races in shallow water and deep water for twelve minutes

Thursday, July 8, 1971 3-4 P.M.

1. Breathing exercises for four minutes in a standing position.
2. Swimming instructions for forty-five minutes, including:
   A. Forty-eight bobs in shallow water
   B. One hundred bobs in deep water
3. Ping-Pong-Puff and Blow-Up races in shallow water and deep water for ten minutes.

Friday, July 9, 1971 3-4 P.M.

1. Breathing exercises for five minutes in a standing position.
2. Swimming instructions for thirty minutes, including:
   A. Fifty bobs in shallow water
   B. One hundred bobs in deep water
3. Free Play for fifteen minutes
4. Presentation of Red Cross certificates and swimming awards for ten minutes.

APPENDIX F

Daily Lesson Plans for Subjects Aged Five Years

DAILY LESSON PLANS

The subjects in the experimental group who were five years of age required individual attention and instruction. Each subject was a beginning swimmer, and the investigator and her assistants employed games in conjunction with the basic skills of swimming. The sessions were conducted for thirty minutes five days a week, for a period of four weeks. The daily lesson plans are presented below, and an explanation of the games appears on pages 145 and 147 of the Appendix.

Monday, June 14, 1971 4-4:30 P.M.

1. Demonstration and practice of abdominal breathing exercises for two minutes in supine position.
2. Individual swimming instructions for twenty minutes, including bobs and correct breathing for swimming.
3. Individual games for five minutes, including London Bridge and blowing bubbles.

Tuesday, June 15, 1971 4-4:30 P.M.

1. Breathing exercises for two and one-half minutes in supine position.
2. Individual swimming instructions for twenty minutes, including bobs, breathing practices, and correct kicking.
3. Games for seven minutes, including London Bridge and Flutter-By with help from the instructors.

Wednesday, June 16, 1971 4-4:30 P.M.

1. Breathing exercises for three minutes in supine position.
2. Individual swimming instructions for twenty minutes, including bobs, breathing practice, and correct kicking.
3. Games for seven minutes, including Ping-Pong-Puff, with help from the instructors.

Thursday, June 17, 1971 4-4:30 P.M.

1. Breathing exercises for three and one-half minutes in supine position.
2. Individual swimming instructions for twenty minutes, including bobs, breathing practice, and correct kicking.
3. Games for six minutes, including Blow-Up, with help from the instructors.

Friday, June 18, 1971 4-4:30 P.M.

1. Breathing exercises for four minutes in supine position.
2. Individual swimming instructions for twenty minutes, including bobs, breathing and kicking practice, and floating.
3. Games for six minutes, including London Bridge.

Monday, June 21, 1971   4-4:30 P.M.

1. Breathing exercises for four and one-half minutes in supine position.
2. Individual swimming instructions for twenty minutes, including bobs, breathing and kicking practice, and floating.
3. Games for six minutes, including Go 'Round and 'Round the Village.

Tuesday, June 22, 1971   4-4:30 P.M.

1. Breathing exercises for five minutes with a book on the diaphram, in supine position.
2. Swimming instructions for twenty minutes, including bobs, breathing and kicking practice, and gliding practice.
3. Games for five minutes, including Flutter-By.

Wednesday, June 23, 1971   4-4:30 P.M.

1. Breathing exercises for five and one-half minutes in supine position.
2. Swimming instructions for twenty minutes, including bobs, breathing and kicking practice, and gliding on front and back.
3. Games for five minutes including Ping-Pong-Puff, with help from the instructors.

Thursday, June 24, 1971 4-4:30 P.M.

1. Breathing exercises for six minutes in supine position.
2. Individual swimming instructions for twenty minutes, including bobs, breathing and kicking practice, gliding, floating, and combinations of learned skills.
3. Games for four minutes, including Blow-Up, with help from the instructors.

Friday, June 25, 1971 4-4:30 P.M.

1. Breathing exercises for two minutes in a sitting position.
2. Individual swimming instructions for twenty minutes, including bobs, breathing and kicking practice, and finning.
3. Games for eight minutes, including London Bridge and Go 'Round and 'Round the Village.

Monday, June 28, 1971 4-4:30 P.M.

1. Breathing exercises for two and one-half minutes in a sitting position.
2. Individual swimming instructions for twenty minutes, including bobs, breathing and kicking practice, and treading water.
3. Games for eight minutes, including Flutter-By and Ring Around the Rosy.

Tuesday, June 29, 1971 4-4:30 P.M.

1. Breathing exercises for three minutes in a sitting position.
2. Individual swimming instructions for twenty minutes, including bobs, breathing and kicking practice, and treading water.
3. Games for seven minutes, including Blow-Up.

Wednesday, June 30, 1971 4-4:30 P.M.

1. Breathing exercises for three and one-half minutes in a sitting position.
2. Individual swimming instructions for twenty minutes, including bobs, breathing and kicking practice, and jumping into shallow water.
3. Games for seven minutes, including relay races.

Thursday, July 1, 1971 4-4:30 P.M.

1. Breathing exercises for four minutes in a sitting position.
2. Individual swimming instructions for twenty minutes, including bobs, breathing and kicking practice, and jumping into deep water with the help of the instructors.
3. Games for six minutes, including relay races with partners.

Friday, July 2, 1971 4-4:30 P.M.

1. Breathing exercises for two minutes in a standing position.

2. Individual swimming instructions for twenty minutes, including bobs, breathing and kicking practice, jumping into deep water, and diving.
3. Games for eight minutes, including Flutter-By, Blow-Up, and Go 'Round and 'Round the Village.

Monday, July 5, 1971 4-4:30 P.M.

1. Breathing exercises for two and one-half minutes in a standing position.
2. Individual swimming instructions for twenty minutes, including bobs, breathing and kicking practice, diving, and the crawl stroke.
3. Games for eight minutes, including Ping-Pong-Puff and relay races with the help of the instructors.

Tuesday, July 6, 1971 4-4:30 P.M.

1. Breathing exercises for three minutes in a standing position.
2. Safety and rescue skills with group instruction for ten minutes.
3. Individual swimming instructions for seventeen minutes, including bobs, kicking and breathing practice, diving, the crawl stroke, and the elementary back stroke.

Wednesday, July 7, 1971 4-4:30 P.M.

1. Breathing exercise for three and one-half minutes in a standing position.

2. Individual swimming instructions for twenty minutes, including bobs, kicking and breathing practice, diving, the crawl stroke, and the elementary back stroke.
3. Games for seven minutes, including relay races.

Thursday, July 8, 1971 4-4:30 P.M.

1. Breathing exercises for four minutes in a standing position.
2. Individual swimming instructions for twenty minutes, including bobs, kicking and breathing practice, diving, the crawl stroke, the elementary back stroke, and swimming underwater.
3. Games for six minutes, including Blow-Up, Flutter-By, and Ping-Pong-Puff.

Friday, July 9, 1971 4-4:30 P.M.

1. Breathing exercises for five minutes in a standing position.
2. Swimming instructions for fifteen minutes in a group, including bobs, breathing and kicking, jumping into deep water, treading water, diving, swimming underwater, and the crawl stroke.
3. Free Play for five minutes.
4. Presentation of Red Cross certificates and swimming awards for five minutes.

APPENDIX G

Description of Breathing Exercises

Description of Games

BREATHING EXERCISES

The respiratory and physical exercises executed at the beginning of each session of the swimming program were outlined by the Asthma Research Council of London, England,[1] Livingstone and Gillespie,[2] and Fein and Cox.[3] A description of each exercise used in the present study appears below.

1. Diaphragmatic Breathing Exercise - Lying.

   The position is lying on the back with knees bent, body relaxed, and hands placed on the abdomen. Breathe out slowly through the mouth, with a whistling or hissing noise, making the chest as small as possible and tightening the abdominal muscles. Relax the abdominal muscles and breathe in quickly through the nose. Repeat.

2. Diaphragmatic Breathing Exercise - Sitting.

   The exercise is performed in the same manner as 1., but the position is sitting up straight.

3. Diaphragmatic Breathing Exercise - Standing.

   The exercise is performed in the same manner as 1., but the position is standing.

---

[1] Asthma Research Council, Physical Exercises for Asthma (London: Headley Brothers, 1934).

[2] Livingstone and Gillespie, "The Value of Breathing Exercises in Asthma," 705-708.

[3] Fein and Cox, "The Technique of Respiratory and Physical Exercise in the Treatment of Bronchial Asthma," 377-384.

4. Side Expansion Breathing Exercise.

The position is on the back with knees bent, body relaxed, and hands placed on the lower ribs. Breathe out slowly through the mouth with a whistling or hissing noise, making the chest smaller, and give a final squeeze with the hands. Breathe in through the nose, pushing the lower ribs out against the pressure of both hands. Relax the pressure at the height of the inspiration, but do not move the upper chest.

5. Elbow Circling Exercise.

The position is sitting with back straight. The fingertips are placed on the shoulders, elbows bent and out to the side, in line with the shoulders. Circle the elbows up, back, and down several times, then relax. Repeat in the opposite direction.

GAMES

The games played by the subjects in the swimming program as mentioned in the Daily Lesson Plans are described below.

1. Bobs - The subjects were instructed to take a breath, sink below the surface of the water and exhale, return to the surface, take another breath of air, and repeat.

2. Ping-Pong-Puff - The subjects were divided into six equal teams. The respective teams were given a ping-pong ball, which was blown across the width of the pool and back by each team member in turn, in relay fashion.

3. Partner Ping-Pong-Puff - This game was played in the same manner as the ping-pong-puff, but each team member had a partner who held his hand and blew the ball with him.

4. Flutter-By - The subjects were divided into six equal teams. The respective teams were given a kick-board. At the signal, the first member of each team held the board in front of himself and executed the "flutter-kick" across and back the width of the pool. Each team member was required to repeat the procedure in relay fashion.

5. Partner Flutter-By - This game was played in the same manner as the flutter-by, but each team member had a partner who also held onto the kick-board and kicked.

6. Blow-Up - The subjects were divided into six equal teams. Each team was given a beach ball, which was blown up by the first member of each team and then batted in front of him as he walked across the width of the pool and back to his team. Each team member was required to deflate the ball, and then repeat the same procedure, in relay fashion.

7. London Bridge - This game was played in the same manner as the singing game, but the subjects were told to "swim under the bridge."

8. Go 'Round and 'Round the Village - This game was played in the same manner as the singing game, but the subjects were told to "swim under the arms of the subjects in the circle."

9. Ring Around the Rosy - This game was played in the same manner as the singing game, but the subjects pulled each other under the water at the end of the song.

10. Keep Away - This game was played in the same manner as the playground game, but the subjects swam under the water in the shallow water and/or deep water. The subjects in the deep water were required to remain in the water during the entire game, which was found to be very strenuous.

APPENDIX H

Table 30

Raw Data

TABLE 30

RAW DATA FOR FEV_1, MBC, AND SWC_{170} TESTS

Subject	Age	FEV_1 cubic centimeters		MBC liters per minute		SWC_{170} seconds	
		Pretest	Posttest	Pretest	Posttest	Pretest	Posttest
E - 1[a]	5	1089	1238	39	37	-	-
E - 2	5	1184	1238	21	17	-	-
E - 3	5	1170	941	29	31	-	-
E - 4	6	1462	1072	30	25	125	125
E - 5	9	817	938	29	32	200	240
E - 6	9	2250	2090	57	50	180	210
E - 7	9	1202	372	32	14	190	150
E - 8	9	1980	1954	51	54	180	180
E - 9	9	1539	1577	52	50	130	130
E -10	9	1419	1513	38	40	170	180
E -11	10	1601	1662	70	62	140	150
E -12	10	2090	2052	66	67	240	240
E -13	11	2350	2026	74	70	185	220
E -14	12	2414	2494	65	85	245	260
E -15[b]	5	961	941	25	27	-	-
E -16	5	1218	1223	33	31	-	-
E -17	5	767	523	15	21	-	-
E -18	6	1587	1672	42	40	180	180
E -19	7	1450	1526	38	52	210	235
E -20	7	1075	1051	35	35	115	150

TABLE 30--Continued

Subject	Age	FEV_1 cubic centimeters		MBC liters per minute		SWC_{170} seconds	
		Pretest	Posttest	Pretest	Posttest	Pretest	Posttest
E -21	7	1333	1261	32	35	125	150
E -22	7	1365	1484	38	42	110	115
E -23	7	1269	1320	37	44	115	120
E -24	7	1180	1045	29	30	120	120
E -25	8	1714	1703	51	58	270	280
E -26	8	1496	1223	31	33	180	190
E -27	8	1421	1223	39	42	120	120
E -28	9	1752	1724	51	55	185	185
C - 1[c]	5	1089	1091	27	30	-	-
C - 2	5	1053	1150	23	21	-	-
C - 3	5	1129	1150	32	30	-	-
C - 4	7	1053	1236	27	21	150	180
C - 5	7	1293	1517	31	42	175	110
C - 6	7	1071	1045	41	36	180	185
C - 7	7	617	631	23	23	148	180
C - 8	7	1406	1548	33	40	168	175
C - 9	8	1818	1954	52	60	175	190
C -10	8	1703	1455	43	42	210	175
C -11	8	1015	1039	37	35	175	180
C -12	8	1091	1050	18	21	138	120

TABLE 30--Continued

Subject	Age	FEV_1 cubic centimeters		MBC liters per minute		SWC_{170} seconds	
		Pretest	Posttest	Pretest	Posttest	Pretest	Posttest
C -13	9	1828	1579	49	37	210	175
C -14	10	1560	1704	47	57	120	125
C -15[d]	5	1024	1031	29	27	-	-
C -16	5	950	946	28	25	-	-
C -17	5	857	862	15	21	-	-
C -18	6	1075	1097	25	38	112	115
C -19	7	1211	1087	26	27	150	90
C -20	8	1765	1527	42	37	125	120
C -21	9	1938	1777	57	59	180	180
C -22	9	1371	1548	35	38	185	180
C -23	9	1986	2048	60	64	178	180
C -24	9	1939	1944	50	57	247	240
C -25	10	1410	1288	33	26	125	150
C -26	10	2232	2116	59	83	190	180
C -27	12	3031	2909	70	59	250	248
C -28	12	2124	2206	53	72	240	230

[a]asthmatic experimental group

[b]non-asthmatic experimental group

[c]asthmatic control group

[d]non-asthmatic control group

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