8-1968

The Effects of a Season of Training and Competition on the Respiratory System of Boys at Dunbar Junior High School

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THE EFFECTS OF A SEASON OF TRAINING AND COMPETITION ON THE RESPIRATORY SYSTEM OF BOYS AT DUNBAR JUNIOR HIGH SCHOOL

by

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A Thesis

Presented to

the Faculty of the School of Physical Education

Prairie View Agricultural and Mechanical College

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

August 1968

DEDICATION

To my Mother and my Brother

I dedicate this Thesis

ACKNOWLEDGEMENT

The writer wishes to acknowledge the assistance given by Mr. Leroy Moore, Mr. Sanuel Lindsay, R. Phillip Young of Prairie View Agricultural and Mechanical College; Mr. James White and students of the Dunbar Junior High School, Beaumont, Texas.

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CHAPTER I

INTRODUCTION

Respiration is the transfer of gases between human organisms and their environment. Our respiratory system serves to provide the oxygen necessary for the essential process of body metabolusm and to rid the body of the carbon dioxide waste. The entire respiratory system is coordinated and regulated by impulses arising in the brain. There are several parts of the respiratory system; they are the mouth, larynx, nose, trachea, bronchi, and lungs. This study will concern itself with the most important and largest organ, the lungs.

The lungs are paired, coneshaped organs in the thoraic (chest) cavity, separated from each other by the heart. In our lungs is a twofold process called breathing. This is really an exchange of gases. This process is controlled by the muscles of the chest and the diaphragm. This exchange of gases is known as inspiration and expiration. During this process the gas containing carbon dioxide is forced from the lungs while a fresh supply of oxygen enters the lungs.

This experimental study is an attempt to determine what effects a season of training and competition will have on the respiratory system of junior high school boys. There have been several studies concerning the vital capacity of the breathing rate and the recovery rate of the lungs of average human beings. These studies have made possible this study.

Most studies were concerned with athletics or the average human beings. However, this study will only be concerned with those junior high school boys who participated in the training program.

In the past, reports have tried and in some cases, proved that certain systems of the body are affected during the courses of a training program. In one study it was proved that the heart of a trained athlete beats at a slower rate than that of a non-athlete, secondly, that the stroke volume of a trained athlete was greater than that of a non-athlete.[1] The above statement being true about the respiratory organs especially the lungs, what effect is this having on the breathing rate, the vital capacity and most of all, what are the advantages or disadvantages?

I. THE PROBLEM

Statement of the problem. The purpose of this study

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[1]W. W. Tuttle, "The Effects of A Season of Training and Competition on the Response of the Heart of High School Boys," Research Quarterly, XI (December, 1940), pp. 78-81.

is to answer four specific questions:

1. What is the breathing rate of a junior high athlete after a training period?

2. What is the recovery rate of a junior high athlete after exercise after a training period?

3. What is the vital capacity of the lungs after a training period?

4. What is the breathing rate of a junior high athlete during the recovery period?

Importance of the study. There are two types of breathing, external or "lung breathing," and internal or "cell breathing."[2] These types of breathing are dependent on one another and the circulatory system. The first type is important because it makes possible the second type of breathing. The second type is equally as important because it makes possible the exchange of gases between the cell. Without the circulatory system, both types of breathing would be useless. The circulatory system carries the gases to and from the cells. Because of the responsibility the circulatory system has in transporting we would think without the changes in both the circulatory and respiratory systems increase or

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[2] Catherine A. Parker, Anatomy and Physiology (New York: C. V. Mosby Company, 1959), pp. 345-372.

decrease in respiratory responses would not be possible.

Physical training produces certain long lasting effects. These effects occur most often in the muscles. As a result of work, muscles increase in size making the muscle stronger and more capable of doing work. Carlton said, "The heart of a trained subject beats slower both during rest and during activity. Changes in the breathing system are somewhat similar."[3] Douglas reported that, the vital capacity of the lungs was higher in athletes than in non-athletes.[4]

If physical training improves the working condition of the body, we are concerned with it to a great extent. Because of our age of automation, the extent of a physical training program is very important. If the working efficiency of our boys and girls bodies is to be improved, when should this program start?

This study can perform two specific tasks. First, as physical education instructors, the results could serve as a guide in the sequence of the educational program. This would enable boys and girls to have a specific standard or base of physical training. Secondly, the physical education and

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[3]Alton J. Carlton and others, Machinery of the Body (Chicago: Chicago Press, 1961), pp. 301-302.

[4]Douglas Stewart, Comparison of Vital Capacity and Maximum Breathing Capacity of Athletes and Non-Athletes (New York: C. V. Mosby Company, 1955), pp. 501-507.

athletic program would be closer related in terms of condition of all boys and girls.

II. HYPOTHESIS

It was hypothesized that the breathing rate would decrease, the vital capacity would increase and the recovery rate of the athlete would be shortened.

III. DELIMITATION OF STUDY

This study concerned itself with ten subjects. These subjects were students at the Dunbar Junior High School of Beaumont, Texas. The students were male students, eighth and ninth graders, between the ages of 13 and 15 years. They were students who worked very hard to win.

These students are members of our athletic teams. They have participated in the football and basketball programs. These seasons were about five months long. In football, they played eight games; in basketball, twenty-one games. Before being able to participate in the athletic programs, each member has to pass a physical examination. Two tests were administered, the first on September 14, 1967, a preseason test. This test was administered at the beginning of football season. The post season test was administered on February 15, 1968, about two weeks before the end of the basketball season.

IV. METHODOLOGY

The instrument employed in this study was the Collins Vitalometer. This instrument consists of a drum inverted over a chamber of water. The drum is counter balanced by a weight. In the drum is a breathing mixture of gases, usually air or oxygen, and a tube connects the mouth with the gas chamber.

Hutchison, a pioneer in the field, invented the spirometer and studied the vital capacity. The investigation was divided into two test periods using the spirometer. Other instruments used were the Kymograph and Pneumograph. The Pneumograph consists of elastic band and clamp usually attached around the abdominal cavity. The Kymograph is a type of graphing instrument used to record the result of the Pneumograph.

The pre-training test period started September 14, 1967. At 3:30 P. M., the subjects, using the above instruments, participated in three tests. The three tests were to investigate vital capacity, breathing rate and the recovery rate following exercises.

During the first test of the pre-training tests, each subject breathe in the spirometer three times. The second test in the pre-training period was that of breathing rate.

Each subject was placed in a Pneumograph that was attached to the Kymograph. As the breath of the individual subjects was taken, these were recorded by the Kymograph. This Kymograph revolved at a rate of 150 m.m. per second. At the end of a one minute period, the number of breaths were counted from the Kymograph.

The third test during these pre-training periods was to investigate the recovery time. The W. W. Tuttle Pulse Rate Step Test was to encourage respiratory responses of the human body. This test has been used to study changes in the Circulatory System, mainly the pulse rate. However, because of the relationship of the system in respiratory function, it was felt this test would stimulate the respiratory responses.

The subjects breathing rate was recorded. The subjects later took part in the step test for a period of three minutes. Using a stop watch, the subjects were timed to see how long it would take to return to their resting breathing rate. The above subjects took a six months training program. This program consisted of a season of basketball and football. At the end of this period, the procedure described above was used to test subjects during the post training testing period. The post training testing period began February 15, 1968. All testing was done at the Lamar Tech College.

Ten male junior high school students were used as subjects. All subjects were members of the football and basketball teams. Ages of the subjects ranged from 13 to 15 years, with a mean age of 14.8.

V. DEFINITIONS OF TERMS USED

Beaumont, Texas. A town located in the area called Southeast Texas. It is located eighteen miles north of Port Arthur, Texas. The industries found here are refineries, rice farming and shipping. This city has a population of 122,119 people.

Comparative study. This is a study involving a group of athletes who entered a training program for some five months. The results from testing will be compared before and after the training period.

Dunbar Junior High School. Refers to that school with an enrollment of about 600 children, between the seventh and ninth grades. This school has a staff of 30 teachers. The faculty is integrated, with 28 Negro teachers and 2 Caucasians. The student population is predominantly Negro. The school is located in the south side of the city.

Pneumograph. An instrument used to measure breathing rate.

Lungs. Two coneshaped, spongy organs of respiration, connected with the pharynx through the trachea, the base rests on the diaphragm and the apex rises to an inch above the collar bone, supported by its attachment to the hilum or root structures. Right lung has three lobes and the left one has two lobes. Weight, 1260 GM; contains 76,000,000 air cells, average 18 respirations per minute in adults, respiration surface, 870 sq. ft., capacity, 20 Cu. in. of air each respiration, 300 Cu. ft. every 24 hours. These figures are for a normal adult.

Athlete. A student who participates in the athletic program provided at the Dunbar Junior High School. This student must meet the requirements set by the University Interscholastic League.

Respiratory System. Consist of those organs that make possible the exchange of gases (CO_2 - O_2) in the air. We would also be concerned with those organs that aid in intercell breathing. Those organs are: the nose, mouth, pharynx, bronchi, lungs and blood.

Season of training. Those activities that are a part of the Dunbar Junior High School athletic program. The length of this training period was six months.

Breathing rate. The number of times the subject breathes in a 60 second period while resting.

Collins Vitalometer. An instrument used to measure the vital capacity of the lungs.

Kymograph. An instrument used to record the rate of breathing.

Vital capacity. The largest quantity of air which a person can expel from his lungs by a forcible expiration after the deepest possible inspiration.

Primary recovery time. The time it takes each subject to return to his normal breathing after an exercise period. This recovery period is an indefinite amount of time.

CHAPTER II

SURVEY OF RELATED MATERIAL

This study will be concerned basically with the effects of a training program on the lungs, as a part of respiratory system, of junior high school boys. In this survey of related material some of the studies will refer to the circulatory system. Because the circulatory and respiratory systems are so closely related in the process of respiration these studies aided the investigator in his study of the complete process of respiration. We are in this study concerned with the vital capacity, the rate of respiration and the recovery rate after an exercise period.

Fall and Webers in their study to determine the oxygen uptake after exercise used five subjects. These subjects rode a bicycle erogometer at a designated rate. The oxygen uptake and heart rate were measured. The informal warm-up exercises were 25 side straddle hops, 10 push-ups, 25 sit-ups, 15 deep knee bends, and 50 repetition of running in place. These exercises were done for a designated period of time. They found that the oxygen uptake during the recovery period after exercise was higher when the subjects were warmed up by exercise than when they were cold. It was further discovered that exercise, heart rate and recovery oxygen uptake were found to be significantly lower after a cold shower than after the other conditions. There was no significant interaction between subjects and pre-exercise conditions on recovery heart rate.[1]

Howard, in his study tried to determine the effects of a lack of a warmup and the presence of a warmup on the heart rate. Eight track athletes were used to make this study. The subjects performed two pairs of exercise routines in which the variable within the pair was the warmup. The heart rate of the subject was continuously related to a recording system by a radiotelemetry transmitter. Howard stated:

> No statistically significant difference was found between the maximum heart rate performed with or without a warmup. The difference between recovery rates and the differences between anticipatory rates were significant. A pronounced bend for the anticipatory increase in heart rate to be limited by the initial heart rate was observed.
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> A small positive correlation between the anticipatory increase in heart rate and the recovery decrease in heart rate was noted.[2]

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[1]H. B. Falls and J. E. Webers, "Effects of the Pre-Exercise Condition on Heart Rate and Oxygen During Exercise and Recovery," Research Quarterly, (October, 1965), p. 243.

[2]Carl S. Blyth, Forden E. Howard and William E. Thorton, "Effects of Warmup on the Heart Rate During Exercise," Research Quarterly, (October, 1966), pp. 361-67.

Shuartz also made a study concerning the heart rate. The purpose of his study was to compare the effects on heart rate of isotonic and isometric exercises, performed for 45 seconds with one-half of the maximum load.[3] Twelve subjects were used. They consisted of ten students and two instructors. In this study several things were indicated. Isotonic exercises and isometric exercises both stimulated the heart rate. Isometric exercises performed for 45 seconds with one-half maximum resistance could stimulate heart rate to the same extent that isotonic exercises could using the same intensity and duration. Maximum tension developed isometrically results in a near two-fold increase in heart size. Proportional increase in heart rate was the results of increasing the load in isometric exercises.[4]

Cureton reported that in various analysis in the area of cardiovascular respiratory tests was studied and the factors grouped into clusters of resting state, change of postural positions from quiet sitting to lying or standing moderate circulatory performing capacity, recuperative ability after exercise, and repspiratory capacity and reserve. The factors from

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[3]Esar Shuartz, "Effect of Isotonic and Isometric Exercises on Heart Rate," Research Quarterly, (March, 1966), p. 121.

[4]Ibid., p. 125.

various studies were affected by the type of subject, the body position, and the relative state of fitness. The various tests in the quiet state indicate relative sympathetic or parasympathetic dominance, blood flow, cardiac output and metabolism. Moderate circulatory performing capacity tests indicate that there is relative economy to the work in terms of lower relative pulse rates, lower blood pressure during work and lower relative oxygen intake for the relatively fitter men. The vital capacity or certain measures of respiratory reserve, have appeared as relatively independent form the factor analysis, of others compared to the circulatory factors, yet it is clear that circulatory and respiratory phenomena are closely related in physiology and internally cannot be separated.[5]

Falls in a study concerning the maximum oxygen uptake used the AAHPER Youth Fitness Test items. This test was administered to 87 adults in hopes of being able to estimate maximum oxygen uptake. This study also served as a means of determining the validity of the AAHPER Youth Fitness Test itsms. Falls reported that:

> 1. Maximum O_2 uptake per kg. body weight can be estimated with reasonable validity from the motor fitness items.

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[5]Thomas K. Cureton, "Comparison of Various Factor Analysis of Cardiovascular-Respiratory Test Variables, Research Quarterly, (October, 1966), pp. 317-22.

2. This study helps to validate the Youth Fitness Test as a test of physical fitness.

3. The best single estimator of maximum O_2 uptake among the Youth Fitness items is 600 yds. run-walk.[6]

Emile, Petit, and Deroanne did a comparative study to explain the mechanical work of breathing. All trained individuals were students of physical education who for several years had participated in a program of systematic and rather strenuous physical activity. The maximum O_2 uptake per kilogram of body weight represents a good index for assessing the effects of training. All trained subjects had higher values of maximum O_2 uptake per kilogram of body weight than untrained individuals. The subjects exercised on a bicycle erogometer at varying work loads, up to a maximum that brought them to exhaustion in 6 minutes. Since reliable measurements of respiratory work done against elastic forces are difficult to obtain, the only data taken into consideration were from these experiments in which endoesophageal pressure during expiration appreciably exceeded the relaxation pressure curve of the chest wall. In the latter circumstance, all potential energy stored in elastic structures in the lungs and chest wall during inspiration was probably utilized in accomplishing

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[6]H. B. Falls, "Estimation of Maximum Oxygen Uptake in Adults," Research Quarterly, XXVII (May, 1966), pp. 192-200.

flow-resistive work during expiration and the total mechanical work of breathing was represented by the work done against pulmonary flow resistance alone. In this circumstance, the only components of respiratory work not represented in the pressure volume measurement is that done in overcoming the viscous resistance of the chest wall. The latter, however, can probably be discounted, as it has been shown to represent in normal subjects only a small fraction of the total work of breathing. Our measurements of mechanical work of breathing include that done on the apparatus. The magnitude of the latter was relatively small. In most experiments, the total oxygen uptake of the body was determined from the analysis of expired gas by conventional methods. All measurements were taken during the sixth minute of exercise.[7]

In a study made by Micheal and Gallen, a one minute step test at 36 steps per minute on a 17 inch bench was given to 17 varsity basketball players each three weeks during a 16 weeks season of physical training, again after 10 weeks of detraining, and after 20 additional weeks of detraining. The results indicated that the recovery pulse rate count made significant changes during the training for a basketball

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[7]G. Millie-Elili, J. M. Petit and R. Deroanne, "Mechanical Work of Breathing During Exercise in Trained and Untrained Subjects," Journal of Applied Physiology, (January, 1962), pp. 43-46.

season. The training caused changes in three weeks and highly significant changes in six weeks. Maximum changes occurred in 16 weeks. After 6 weeks of training, plateau was reached and no significant changes occurred when training was continued an additional 10 weeks. Three weeks of lay-off after 10 weeks of training caused a reversal of the recovery pulse but the change was not statistically significant. Three additional weeks of training again improved the fitness level to a maximum point. In ten weeks of detraining, the circulatory changes had reversed significantly so that conditioning was not maintained when daily workouts stopped. The one-minute after-exercise pulse count and the sum of the one, two and three minute recovery pulse rate changed in a parallel fashion during physical conditioning for basketball. The pulse rate did not recover to the resting level for five minutes following the exercise when the training program was not being followed. During the training period, however, the pulse rate had recovered by the second and third minutes after the exercise.[8]

Faulkner made a comparison study on the heart rate of students during physical education. In this study, eight

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[8]Earnest D. Michael and Arthur Gallon, "Periodic Changes in the Circulation During Athletic Training As Reflected by a Step Test," Research Quarterly, (October, 1959), pp. 303-311.

training subjects walked 10 minutes, at which time was orbit rarely stopped. Six others who had participated in varsity athletics more than 3 years previously were also able to walk for 10 minutes. Although one stopped because of consistent chest pain, twelve of the 14 untrained, normally walked for less than 180 seconds, at which time they had to stop because of weakness of the legs, fatigue or breathless. The heart rate has been used effectively to determine the stress of physical work tasks in industry and athletics. The pilot study in the youth fitness program has indicated that (1) the mean heart rate of a random group of participants varies among different activities, (2) the mean heart rate of individual participants vary greatly while exposed to the same class structure. The heart rate does appear to give some index of the involvement of the child.[9]

Elsner and Carlson, in a comparative study of athletes and non-athletes, reported:

> Oxygen consumption before, during, and after exercises was the same in all subjects regardless of previous training. The heart rate of non-athletes was higher than that of athletes. In experiments on the non-athlete before and after training the same differences in heart rate and blood flow were demonstrated. No change in the recovery rate of blood flow or heart rate was produced by the prolonged exercise.[10]

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[10]Robert W. Elsner and Loren D. Carlson, "Post-exercise Hyperemia in Trained and Untrained Subjects," Journal of Applied Physiology, (January, 1962), pp. 436-438.

Kreuzer, in his study on physiological adjustment to exercise, said that during a steady state the beginning exercises require an immediate supply of energy, and metabolism raises at once. The uptake of O_2 is increased immediately, but the necessary amount O_2 to cover the energy cost of work lags due to the slow rate of blood flow. In the sustained exercise (steady state), this is a state where the attainment and maintenance of the stability of metabolism and O_2 consumption is constant. No steady state can ever be reached without exhausting exertion which can be maintained for only a few minutes. Maximal O_2 uptake is not equivalent with steady state because it may be accomplished by further accumulation of O_2 debt which eventually limits the continuation of work. The recovery of the heart, circulation and respiration after some minutes will occur, but blood and the nervous system require a much longer time.[11]

Krestomukev says, "Recovery should be tried by using a different set of muscles."[12]

Best says the effects of muscular exercise upon the heart rate varies in different persons. In these trained to

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[11]Ferdinand J. Kreuzer, "Physiological Adjustment to Exercise," Jokl and Sumon International Research in Sports and Physical Education, 1961), pp. 322-334.

[12]B. Krestomukev, The Machinery of the Body (New York: McGraw-Hill Book Company, 1961), p. 45.

muscular work, the heart accelerates markedly, a rate of from 110 to 120 beats per minute being not unusual, whereas the heart of the athlete may show little or no acceleration during muscular beats of highly exacting character. Through the respiratory and circulatory mechanisms just described, the maximum lead of oxygen supply is further augmented through the effects which the carbon dioxide and lactic acid produced in muscle, and the local rise of temperature exert upon the liberation of oxygen from oxyhemoglobin.[13]

Carlson's study reported that, physical training produces certain long lasting effects. Primary among these is upon the muscles themselves. They grow to a larger size by virtue of an increased size of the individual's fibers comprising the muscle. This makes the muscle stronger and more capable of doing its work. In addition training modifies the circulatory and respiratory responses. The heart increases somewhat in size and in the trained subject beats more slowly both during rest and during activity. Changes in the breathing system are somewhat similar. The trained subject breathes more slowly but more deeply than the untrained, and the increase in respiratory exchanges during exercise is accomplished to a

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[13]Charles Best and Normal Taylor, "The Living Body," Journal of Applied Physiology, (February, 1963), p. 45.

greater extent by an increased depth than an increased rate of breathing. As a result of this will enable the trained subject to bring oxygen to the active muscle cell and to eliminate waste from those muscles more effectively and rapidly. Reduction in lactic acid accumulation is probably a factor also in delaying the onset of fatigue in the physically trained individual.[14]

Clark Gorden and several other educators concerned with how exercises effected the brain of humans decided to make a study concerning the circulatory and respiratory function in the cerebral cavity during exercises. Respiratory and cerebral hemodynamic responses to leg exercise during respiration of air were studied in relation to changes in arterial and internal jugular vein's blood oxygen composition. The purpose of the study was to investigate whether exercise, like hypercapnia shortens the latent period of oxygen poisoning by increasing the oxygen pressure to which the brain is exposed. After reading the findings there was a slight elevation of cerebral blood flow or a reduction in the rate of cerebral oxygen consumption during exercise breathing. Cerebral hemodynamics and oxygen consumption were not altered by

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[14]Alton J. Carlson, Victor Johnson, H. Mead Caver, <u>Machinery of the Body</u> (Chicago: Chicago Press, 1961), p. 302.

exercise.[15]

Wyndham, Morrison and Peters, in an investigative study, reported that, "Given a rate of work replaced observations of oxygen intake or heart rate will result in a series of values of these two measurements which will scatter some true mean values."[16]

Steward and Douglas administered a comparative study concerning the vital capacity and maximum breathing capacity. The purpose of this study was to compare the vital capacity and maximum breathing capacity of athletes and non-athletes. A spirometer attached to a Kymograph may be used to discover the vital capacity. To measure the MBC a two-way metal stopcock was attached to the neck of a 100-liter Douglas bag and the free vertical limb of this stopcock attached to the expulsion limb of a high velocity-low resistance value. Their findings suggested the vital capacity score of the athletes were higher than that of the non-athletes. However, there seem to have been very little change in maximum breathing rate.[17]

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[15]Gordon Clark, Abraham Lurie, Herbert Owens, "Respiratory and Cerebral Circulatory Control During Exercise," Journal of Applied Physiology, (1959), pp. 66-97.

[16]C. H. Wyndham, N. B. Strydom, "Maximum Oxygen Intake and Maximum Heart Rate During Strenuous Work," Journal of Applied Physiology, (November, 1959), pp. 929-36.

[17]Douglas Steward and W. D. Collins, "Comparison of Vital Capacity and Maximum Breathing Capacity on Athletes and Non-Athletes," Journal of Applied Physiology, (1959), p. 507.

CHAPTER III

ANALYSIS OF DATA

It has been pointed out previously that this study is concerned with determining the effect that a season of training and competition of basketball and football would have on the respiratory system of boys at Dunbar Junior High School, Beaumont, Texas. Ten members of the Dunbar Junior High football and basketball teams were used as subjects. This combined program consisted of eight football games and twenty-one basketball games. In order to attain any results, two testing periods were necessary. These were the pre-testing period before any training took place, and the post-testing period, after the training period.

The subjects were first tested September 14 through September 23, 1967. This test was necessary to try and determine the starting point of each subject. The subjects were retested February 15 through February 21, 1968. This test was necessary in determining the progress of the subjects. Thursday and Friday were designated as the official test day in both testing periods. These test periods were concerned with three basic factors; vital capacity, breathing rate and recovery rate. After completing both testing periods, the results of the two tests were compared.

Because subjects were not selected at random, the significance of the data must be judged from the variability of the data. So that the test results are easily read and interpreted, tables were prepared. These tables show the physical state of the subjects, either before or after the testing period.

TABLE I

VITAL CAPACITY OF LUNGS BEFORE TRAINING

Subjects	1st Reading	2nd Reading	3rd Reading	Vital Capacity
A	1.8 liters	1.7 liters	1.8	1.8
B	2.4	2.3	2.2	2.3
C	1.6	1.5	2.0	1.7
D	1.7	1.9	1.5	1.7
E	2.3	2.0	2.2	2.1
F	1.9	2.2	2.1	2.1
G	1.6	1.7	1.6	1.6
H	1.5	1.2	1.8	1.6
I	2.2	2.3	2.4	2.3
J	2.1	2.4	2.3	2.3

Range 1.6 - 2.3

Mean 1.93

During the pre-testing of subjects, the subjects averaged 14.3 years of age with a range of 13-15 years. They also averaged 69 inches in height, with a range of 67-71 inches, and averaged 152.5 lbs. with a range of 130 to 175 lbs.

Following the post-testing of subjects, they averaged 14.8 years of age, with a range of 14-15 years. The subjects averaged 71 inches in height, with a range from 67-74 inches. They also averaged 155 pounds in body weight with a range from 133-178 pounds.

The data, with regards to vital lung capacity before the training period are presented in Table I. Alphabets A-J were the subjects being used in the study. For each subject there are four readings. These readings are listed as reading one, reading two, reading three, and vital capacity. The readings, with the exception of vital capacity, were made by the Collins Vitalometer and were recorded in liters. The first three readings represent the capacity of the subjects lungs, as an expiring breath was taken. In the fourth column, these figures represent an average of each subject's first three columns. This average reading is the vital capacity of each subject's lungs.

After studying Table I, several things were noticeable.

First, the high reading of capacity on an expiration breath was recorded on the second reading. The lowest reading of capacity on an expiration was recorded on the first reading, while the third reading comes the closest to vital capacity. Secondly, we found the vital capacity to range from 1.6 liters to 2.6 liters. This gave the entire group a mean of 1.93 liters.

Table II attempts to show the vital capacity of the subjects lungs following the training period. Alphabets A-J are the subjects being used in this study. For each subject there are four readings. These readings are listed as reading one, reading two, reading three, and vital capacity. These readings, with the exception of vital capacity, were made by the Collins Vitalometer and were recorded in liters. The first three readings represent the capacity of the subjects lungs as an expiring breath was taken. In the fourth column, the figures represent an average of each subject's first three columns. This average reading is the vital capacity on each subject's lungs. After studying Table II, several things were noticeable.

First, the highest reading of capacity on an expiration breath were recorded on the third reading, while the lowest reading of capacity on an expiration breath was recorded on the first breath. Both the second and third readings seem to dictate the vital capacity. Secondly, it was found that vital capacity ranged from 1.9 liters to 1.28 liters. This gave the entire group a mean of 2.2 liters.

TABLE II

VITAL CAPACITY OF LUNGS AFTER TRAINING PERIOD

Subjects	1st Reading	2nd Reading	3rd Reading	Vital Capacity
A	1.8 liters	2.0 liters	2.0 liters	1.9 liters
B	2.4	2.7	3.0	2.7
C	2.1	2.4	2.4	2.3
D	1.6	2.1	2.3	2.0
E	2.4	2.3	2.2	2.3
F	2.1	2.5	2.3	2.3
G	2.2	1.9	1.8	1.9
H	2.0	1.9	1.9	1.9
I	2.4	2.3	2.6	2.4
J	2.7	2.5	2.8	2.8

Range 1.9 - 2.8 liters

Mean 2.2 liters

The following table is concerned with comparing Table I and Table II. In this table some changes will be noticed because of individual differences. The alphabets are used in the same manner.

The second column is the vital capacity of each subject before the training period. Column three represents the vital capacity of each subject after the training period. The last column is concerned with the difference in progress of each individual subject made as a result of the training period. In studying our range, we see it going from 1.6 liters to 2.3 liters before training to 1.9 liters - 2.8 liters after training. The lower range in vital capacity was increased by .3 liters, while the upper range in vital capacity was increased by .5 liters. We also see the mean going from 1.93 liters before training to 2.23 after the training period. This change also indicates .30 liters increase in the mean of the entire group.

Looking at the difference in individual vital capacity of the lungs as a results of training, we are able to see only increases. Becuase of several factors, the differences can be justified. However, none of the increases are what one would expect as a results of a six months training period. For these individual differences we saw the range fall between .1 liter to .6 liter. We also found the mean of the entire group about .30 liters.

The tests were administered to determine three things; the breathing rate of the lungs, vital capacity and recovery rates. This testing period will be concerned with the breathing rate of the lungs of the subjects. These rates were determined by the use of two instruments, Kymograph and Pneumograph.

TABLE III

COMPARISON OF VITAL CAPACITY BEFORE AND AFTER TRAINING PERIOD

Subjects	Vital Capacity Before Training	Vital Capacity After Training	Increase or Decrease in Vital Capacity
A	1.8	1.9	+ .1 liters
B	2.3	2.7	+ .4 liters
C	1.7	2.3	+ .6 liters
D	1.7	2.0	+ .3 liters
E	2.1	2.3	+ .2 liters
F	2.1	2.3	+ .2 liters
G	1.6	1.9	+ .3 liters
H	1.6	1.9	+ .4 liters
I	2.3	2.4	+ .1 liters
J	2.3	2.8	+ .5 liters

Range:	1.6 - 2.3 liters	1.9 - 2.8 liters	.1-.6 liters
Mean:	1.93 liters	2.3 liters	.30 liters

As a Result of Training Some Increases:

Range Increase .3 - 5 liters

Mean Increases .30 liters

The Pneumograph was attached to the Kymograph to mark the number of times a subject breathes. Because we are able to control breaths or the rate of breathing, the subjects relaxed before the count started. We were able to assume a state of relaxing when the breathing sequence was continuous. From related studies, we would expect the breathing rate of subjects to decrease because of the training period.

Table IV will show by comparison the results of the two tests, the breathing rate before and after training and the mean of the two testing periods, and some individual differences in breathing rate. The alphabets A-J are subjects who are taking part in the study.

The second column represents the number of times each subject breathes in one minute before training. If we look closely, we would see on a whole, that the group if closely related with the exception of C and G. We also note the average number of breaths taken by this group to be about 27 per minute. The range of breaths taken by this group was from 19-32 breaths per minute.

The third column represents the number of times each subject breathes in one minute after the training period. We find the average number of breaths taken by this group after the training period to be about 24 breaths per minute. The range of breaths taken by the group was from 19 - 32 breaths before the training period, to 19 - 28 after the training period. This indicates that the group, as a whole, is closely centered to a common number of breaths per minute.

TABLE IV

BREATH RATE BEFORE AND AFTER TRAINING PERIOD

Subjects	Breathing Rate Before Training Program	Breathing Rate After Training Program	Individual Differences
A	25 times/min.	25 times/min.	same
B	28 times/min.	23 times/min.	5
C	32 times/min.	27 times/min.	5
D	28 times/min.	20 times/min.	8
E	26 times/min.	24 times/min.	2
F	28 times/min.	28 times/min.	same
G	19 times/min.	19 times/min.	same
H	26 times/min.	23 times/min.	3
I	25 times/min.	25 times/min.	same
J	28 times/min.	28 times/min.	same
	Range 19 - 32	Range 19 - 28	Range 2-8 breaths
	Mean 26.3	Mean 24.3	Mean 4.7

As the results of training period - decreases:

Range 0 - 4

Mean 2

While the lowest number of breaths remain the same, the highest number decreased by 4 breaths per minute. The fourth column representing individual differences in breath rate indicates five subjects remaining the same, while five changed. The range indicated a decrease ranging from 2 to 8 breaths per minute. This was a decrease of five breaths per minute.

Table V shows the recovery rate or the time each subject needed to return to his normal breathing rate. These figures were taken by recording the normal breathing rate. After this recording, the subjects took part one by one, in physical exercise (step test), which lasted three minutes. At the completion of this exercise, the breathing rate was tested every minute until the subject had returned to his normal rate of breathing. As soon as the normal rate of breathing was reached, a record of minutes taken was recorded. This same procedure was used in both pre-testing and post-testing.

The purpose of this test was to determine how the training period would effect the recovery rate of subjects. In studying the table, it was found that all subject's recovery rate ranged from 2 - 6 minutes. One subject out of the ten had a recovery rate of two minutes, while one subject had a recovery rate of 6 minutes. These two rates determine the recovery range.

The mean rate for the entire group was 3.3 minutes in recovery before the training period. After the training period, the same test was administered to the group. In studying these results we found the range decreasing from 2 - 6 minutes to 2 - 4 minutes. This would indicate a change only at the high phase of the range.

TABLE V

PRIMARY RECOVERY RATE BEFORE AND AFTER TRAINING PERIOD

Subjects	Rate Before Training Period (Minutes)	Rate After Training Period (Minutes)
A	4	4
B	3	2
C	4	4
D	5	3
E	4	3
F	3	2
G	6	4
H	4	3
I	3	2
J	2	2

Before Training Period	After Training Period
Range 2 min. - 6 min.	Range 2 min. - 4 min.
Mean 3.3 min.	Mean 2.7 min.

The training period caused the recovery rate to decrease by about two minutes. Also, in studying this post-training test, the mean changed from 3.3 minutes before the training period to 2.7 minutes after the training period. This also indicated a decrease of 6 minutes in the rate of breathing.

As a result of the data presented, several changes were indicated. In comparing results of the first test, it was found that a small increase was evident in the vital capacity of the lungs. This would indicate an enlargement of the lungs.

But in comparing results of the next test, (breathing rate), it was found that some of the subjects rate of breathing changed. All things remaining the same and an increase in lung size should give a change in breathing rate. This did not happen with all subjects involved. The same thing was noticeable in the recovery rate test. Some of the subjects made changes, while some of them remained at their same physical state.

The writer, in summarizing, feels that these tests have proved that the training period helped these subjects participating to improve the organs of their respiratory and circulatory system. These tests also indicated an increase in size of the organs or the respiratory system. An increase in vital capacity, a decrease in breathing rate and recovery were also observed. However, because of the extent of change in the factors tested and the different responses of individual subjects, consideration must be given to other factors in individual environment.

CHAPTER IV

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

SUMMARY

This investigation was concerned with the responses of the lungs and other respiratory organs of a junior high athlete before and after a season of training and competition.

The major purposes of this investigation were as follows:

1. To determine what the effects of strenuous exercises, such as athletic training and competition would have on the vital capacity of the lungs of junior high school boys.

2. To determine if there is any difference in the breathing rate as a result of the training period.

3. To determine what changes occur in the recovery time as a result of the training period.

The important point brought out by this investigation was that the training schedule, and a season of competition participated in by the subjects investigated did cause some changes in vital capacity, breathing rate, and recovery time.

The changes in the recovery time seem to indicate that the junior high school boy did derive some good by participating in the training program since fewer breaths were required to establish the resting level. In this testing, wherever a trend occurred it favored the efficiency of the respiratory system.

CONCLUSION

On the basis of this investigation, several conclusion statements are made:

1. The oxygen uptake is increased. So vital capacity of the lungs was increased.

2. The recovery time was less after the season, indicating there was an improvement in physical condition as shown by the fact that fewer breaths were required in returning to the resting level.

3. The breathing rate of junior high school boys was decreased by the effects of a season of training.

5. Wherever the data showed trends toward altered cardiac response, it was always in favor of more efficient respiratory action.

RECOMMENDATIONS

In light of the summary of the findings and conclusion, several recommendations were made:

1. This study should be continuous in the high school using the subjects indicated to compare high school performances with junior high.

2. The program of Physical Fitness Education at Dunbar Junior High School should place greater emphasis on physical training.

3. Tests of this nature should be made on the college level.

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