AGE TRENDS IN HEART RATE VALUES DURING AND AFTER SUBMAXIMAL WORK IN WOMEN 30 - 50 YEARS OLD

Thesis for the Degree of M. A.

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Eleanor H. Marine

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AGE TRENDS IN HEART RATE VALUES DURING AND AFTER SUBMAXIMAL WORK IN WOMEN 30 - 50 YEARS OLD

By

Eleanor H. Marine

AN ABSTRACT OF

A THESIS

Submitted to
Michigan State University
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ABSTRACT

As the population of the world continues to enjoy increased life expectancy, the problems of ageing will become increasingly important. There is, however, a scarcity of information related to the effects of ageing on bodily functions and bodily structure.

The primary purpose of this study was to investigate age associated changes in heart rate values during and after a submaximal work test for evaluating physical fitness of women 30 to 50 years old. Closely related purposes were to study the effect of the level of physical activity in daily life and body composition on the heart rate during and after a submaximal work test.

Forty female volunteers between the ages of 30 to 50 with ten women in each five year age group were tested on an eight inch step test for three minutes duration at a rate of twenty-four repetitions per minute. Heart rate recordings were taken on a Sanborn Twin-Viso Recorder at rest, during exercise and during an eight minute recovery period.

The level of physical activity in daily life was determined by a recall questionnaire in which each subject gave information on her homemaking, leisure time and occupational activities. This information was subjectively evaluated to assign each subject an activity rating of light, moderately active, active, or very active.

Height, weight, and pubic skinfold measures were taken for each subject. From these measures per cent of standard weight, predicted specific gravity and fat free body weight were determined.

The data was analyzed by use of charts, graphs, and correlation analyses. Coefficients of correlation were obtained for the relationship between (1) age and maximum heart rate during exercise, and (2) weight and maximum heart rate during exercise.

The data obtained suggested the following conclusions for the subjects in this study:

(1) There is no clear indication of a relationship between level of physical activity in daily life and heart rate during a submaximal work-test.

(2) Body weight, per cent of standard weight, per cent of fat of body weight, and fat free body weight were

greatest in the 35-40 year age group and were progressively less in the 40-45 and 45-50 year age groups.

(3) The subjects were a select group in terms of weight with eighty per cent having per cents of standard weight less than 100 per cent.

(4) There seems to be no distinct age trend in maximum heart rates during exercise. The youngest age group (30-35) had the fastest response to exercise and the most rapid recovery of any age group.

(5) A correlation coefficient of .214 showed a slight relationship between maximum heart rate and weight of the subjects.

(6) A high positive correlation between total body weight and fat free body weight was present. This, in addition to the subjects with the least amount of fat free body weight having the greatest heart rate recovery, indicated a relationship between total body weight and heart rate recovery.

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CHAPTER I

INTRODUCTION

With the life expectancy of the world's population continuing to increase, the biological and social aspects of ageing become increasingly important. Many individuals are living longer lives relatively free from disease; but, while the freedom from disease is a tremendously important factor in health and fitness, the ability of the individual to function with vigor and vitality at any age is essential for the total well-being of the individual and the strength of the nation.

There is also a practical interest in investigating factors affecting fitness. It is useful to estimate the capacity of older individuals in leisure activities outside the home and in different occupational tasks. Despite increased mechanization and automation in industry there are still many occupations which demand moderately severe or severe muscular activity and consequently a considerable degree of physical fitness. Determining the physical capacity or fitness of individuals and understanding how this capacity varies in different age groups and in the two sexes

is one way to estimate the available manpower of the nation.

The physical capacity or fitness of the individual is the result of numerous factors such as innate potential of physiologic mechanisms, age, sex, health and nutritional status, physical condition and the specific fitness for a given task and for given environmental conditions. The quantitive measurement of physical fitness is very complex and one of the most controversial problems in applied physiology.

Schneider stated in 1940 that there was no simple definition of physical fitness since there are no simple tests that measure more than a few kinds of fitness.[1] Darling states that "Fitness apparently consists in the ability of the organism to maintain the various equilibria as closely as possible to the resting state during strenuous exertion and to restore promptly after exercise any equilibria which have been disturbed".[2] Brouha, Fradd and Savage state that

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[1]Schneider, E. C., Physiology of Muscular Activity, (Philadelphia: W. B. Saunders Company, 1940). p. 353.

[2]Darling, R. C., "The Significance of Physical Fitness", Archives of Physical Medicine, as cited by Irma Astrand, "Aerobic Work Capacity in Men and Women with Special Reference to Age", Acta Physiologica Scandinavica, Vol. 49, Supplementum 169, 1960, p. 79.

functional or dynamic fitness is the ability to sustain strenuous exercise and to recover from it rapidly. Such fitness suggests that the general physical machinery of the body is working well and that efficient blood circulation, sound respiratory fitness and good muscular coordination is present. They further state that such fitness is difficult to estimate because it involves knowledge of the functional capacity of many physiological mechanisms when placed under the stress of muscular activity.[3]

Although it is evident that physical fitness is vital to the general well-being of the individual, there is a scarcity of information as to how many factors affect this fitness. Many research workers believe that the best tests to use in studying fitness are those that are easy to perform and give a widespread score between the fit and unfit individual. It is expected that the physically fit person can perform a given grade of light, moderate and exhaustive work more efficiently and with less displacement of his physiological equilibrium than the unfit individual.

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[3]Lucien Brouha, Norman W. Fradd and Beatrice M. Savage, "Studies in Physical Efficiency of College Students", Research Quarterly, Vol. 15, 1944, p. 211.

For maintaining a normal equilibrium in the different tissues under varying conditions an adequate blood supply will always be one of the most important prerequisites. Heart rate values during work and during recovery are well recognized by experts as being an accurate means of evaluating the severity of the physical activity and the strain which activity puts on the cardiovascular system.

Heart rate values during work as well as during recovery are individual characteristics dependent on the physical fitness of the subject. The more fit individuals have lower resting pulse rates, exhibit smaller increases in pulse rate during work and return to the resting level more rapidly after exercise.[4]

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[4]Arthur H. Steinhaus, "Chronic Effects of Exercise", Physiological Reviews, Vol. XIII, No. 1, 1953, pp. 112-114.

PURPOSE OF THE STUDY

The primary purpose of this study was to investigate age trends in heart rate values during and after a submaximal work test for evaluating physical fitness of women 30 to 50 years old. Closely related purposes were to study the effect of the level of daily physical activity and body composition on the heart rates during and after a submaximal work test.

NEED FOR THE STUDY

Data on physical fitness and performance capacity of women of different ages are scanty although these figures are available for men.

There is a need to study the interrelationships of ageing, physical exercise, and body composition on man's functional capacity and performance level. Research in this area can provide basic information for understanding human biological individuality. It is also a way of estimating the available manpower in different age groups and in the two sexes.

DEFINITION OF TERMS

Submaximal Work Test

The submaximal exercise test used in this study was designed for subjects of all ages and both sexes. The subjects stepped on and off a platform eight inches high, twenty-four times per minute for three minutes. At the completion of the exercise the subjects sat in a chair for an eight minute recovery period.

Physical Activity Recall Record

By use of a personal activity questionnaire given by interview method and appropriate energy cost tables the total daily energy expenditure was subjectively estimated for each subject. Each subject was rated on a four level scale of light, moderately active, active, or very active.

Social Status Index

A social status index is a means of approximating the "position" of a person in regard to their socioeconomic level. The Index used in this study is the Index of Social Status--Short Form devised by McGuire and White.[5]

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[5]Carson McGuire and George D. White, "The Measurement of Social Status" Research Paper in Human Development, No. 3 (revised), Department of Educational Psychology, The University of Texas, March, 1955, p. 3.

Per Cent Standard Weight

The actual weight of each subject was expressed as a percentage of standard weight. The "standard" weight was defined as the average weight of the individuals of the same sex, age and height as reported in the Build and Blood Pressure Study, 1959.[6]

Skinfold Thickness

The skinfold thickness is a measure of the subcutaneous fat. By measurement of the skinfold thickness in the "pubic" site (halfway between the umbilicus and the pubis)[7] it is possible to calculate an estimate of total body fat in a young female subject.

Predicted Specific Gravity

Specific gravity of the individuals was predicted by using the following formula[8]:

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[6]Build and Blood Pressure Study, 1959, (Chicago: Society of Actuaries) as reported by Millicent L. Hathaway and Elsie D. Foard in Heights and Weights of Adults in the United States, Home Economics Research Report #10, Agricultural Research Service, (United States Department of Agriculture) Washington, D. C., August, 1960, p. 11.

[7]Committee on Nutritional Anthroponetry of the Food and Nutrition Board, Nutritional Research Council, in Body Measurements and Human Nutrition, J. Brozek, Ed., (Detroit: Wayne University Press, 1956).

[8]Young, Charlotte, Elizabeth Martine, R. Tensuan, and Joan Blondin, "Predicting Specific Gravity and Body Fatness in Young Women", Journal of the American Dietetic Association, Vol. 40, February, 1962, p. 105.

$$\text{Specific gravity} = 1.0834 - .0004231_{x1} - .0003401_{x13}$$

where X_1 = skinfold at pubic site (in mm)

X_{13} = percentage "standard" weight.

Per Cent of Fat of Body Weight

Body fat content was calculated from predicted specific gravity using the Rathbun-Pace[9] formula:

$$\text{per cent fat} = 100 \left(\frac{5.548}{\text{specific gravity}} - 5.044 \right)$$

Fat Free Body Weight (Lean Body Mass)

Fat free body weight was calculated by subtracting the kilograms of fat from the total body weight.

LIMITATIONS OF THE STUDY

1. The test group included only ten subjects in each age group. This number is too small to infer conclusions for a larger population.

2. The subjects were not randomly selected but were volunteers from the metropolitan Lansing, Michigan area. It is likely that subjects volunteering for a study of this type might not be completely representative of the population at large.

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[9] Pace, N., and Rathbun, E. N., "Studies on Body Composition. 3. The Body Water and Chemically Combined Nitrogen Content in Relation to Fat Content", Journal of Biological Chemistry, Vol. 158, 1945, p. 690.

3. The method used to determine the individual's level of physical activity was a recall questionnaire and personal history. The recall of an individual over a prior year is perhaps subject to error but it is hoped that the questionnaire was sufficiently extensive to minimize possible error. In addition the rating scale used to assign activity levels to the subjects was subjectively devised.

CHAPTER II

REVIEW OF THE LITERATURE

There is little detailed information pertaining to controlled research of age associated changes in heart rate values during and after exercise in female subjects. This review shall present some of the most significant studies of heart rate as a measure of work output, age associated changes in heart rate during submaximal work, training effects on heart rate, and the effects of selected measures of body composition on heart rate.

Heart Rate As A Measure of Work Output

There is a linear relation between work load, oxygen consumption and heart rate in the range of normal temperatures (65° to 80°f): the heavier the load, the greater the energy expenditure and the faster the heart rate. Dill found a straight line correlation between heart rate and energy expenditure.[1] Erickson, Ernst, Taylor, Alexander and Keys found a correlation of .972 between heart rate and energy expenditure.[2]

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[1]D. B. Dill, "Effects of Physical Strain and High Altitudes on the Heart and Circulation", American Heart Journal, Vol. 23, 1942, p. 442.

[2]Lester Erickson, Ernst Simonson, Henry L. Taylor, Howard Alexander and Ancel Keys, "The Energy Cost of Horizontal Grade Walking on the Motor Driven Treadmill", American Journal of Physiology, Vol. 145, 1946, p. 399.

Taylor considered the heart rate to be a good indicator of the severity of physical activity and stated that the level of the heart rate during exercise is proportional to the work load. He found correlations of .969 and .955 between heart rate and work load.[3]

Further supporting the use of heart rate as a measure of work output, Wahlund found that the pulse rate increased in a linear fashion with increasing work loads.[4] On the basis of these findings it can be stated that the heart rate increases with the severity of the exercise. It has been shown that the heart rate increases fairly rapidly at the beginning of exercise and then stabilizes at a maximum rate depending on the severity of the work and age, body weight, physical condition and environmental temperature. During recovery from exercise the heart rate drops rapidly at first and then gradually until it reaches the resting level.[5]

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[3] Craig Taylor, "Studies in Exercise Physiology", American Journal of Physiology, Vol. 135, 1941, p. 41.

[4] Holger Wahlund, "Determination of the Physical Working Capacity", Acta Medica Scandinavica, Supplementum 215, 1948, p. 21.

[5] C. Frank Consolazio, Robert E. Johnson, and Louis J. Pecora, Physiological Measurements of Metabolic Functions in Man, (New York: McGraw-Hill Book Company, 1963), p. 355.

Benedict and Parmenter studied the energy metabolism of women in various types of activity. They state that the total energy expended in climbing stairs is a product of the number of gram calories required to lift one kilogram one vertical meter X the individual's body weight X the total meters ascended.[6]

Hodgson calculated work to be done by the following formula:

Body Weight X Height of Step X Number of Steps = Foot Pounds of Work.[7]

Both of these studies took the individual's body size into account in order to determine the work load. The first did it to determine the amount of energy expended by various individuals in a standard level of work; the other to vary the work load so that each individual would be expending the same total amount of energy.

In regard to heart rate values and work load, it is

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[6]Francis G. Benedict and Hazeltene Stedman Parmenter, "The Energy Metabolism of Women While Ascending or Descending Stairs", American Journal of Physiology, Vol. 84, 1928, p. 695.

[7]Pauline Hodgson, "Studies in the Physiology of Activity: I. On Certain Reactions of College Women to Measured Activity", The Research Quarterly, Vol. VII, 1936, p. 6.

apparent that the greater the weight of the subject, the greater the energy expenditure must be to accomplish a given task involving lifting the body weight, thus resulting in increased heart rates during work.

It should be noted, regardless of average or normal responses of the heart, that there is a wide variation among individuals in their response to both submaximal and maximal work necessitating the use of large groups of subjects in conducting experiments involving heart rate and work.

Heart Rate Values During Submaximal Work And Age Associated Changes

The heart rate during submaximal work appears to be remarkably uniform for a given individual under given environmental conditions. Dill reported two sets of experiments in which the external temperature was kept constant (0° to 50°C, the humidity at higher temperatures was kept at 50 per cent).[8] Heart rate was recorded after ten minutes of graded work on a bicycle ergometer. The work load ranged from 0.6 to 2.6 liters of oxygen per minute. Dills results showed that the heart curves were reliable with a probable

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[8] Dill, op. cit., pp. 445-447.

error of not more than two or three beats per minute.

In a modification of the Harvard Step Test, Rhyming set the bench height at 33 centimeters and the rate at twenty-two and one-half repetitions per minute for women.[9] The normal average values for women which Rhyming found in that test was a pulse rate of 140 ± 1.6. In addition, Rhyming presented data which indicated that the mechanical efficiency did not change with body weight or height.[7]

In a later study Rhyming collaborated with P. O. Astrand to construct a nomogram for calculating physical fitness from the pulse rate during submaximal work.[10] Their work made it possible to predict the maximal oxygen consumption of healthy individuals between the ages of eighteen and thirty years by measuring the heart rate and oxygen consumption during a submaximal work test. They stated that the best results would be obtained when the work load is of such severity that the heart rate during steady state is between 125 and 170 beats per minute.

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[9] I. Rhyming, "A Modified Harvard Step Test For The Evaluation of Physical Fitness", Arbeitsphysiologie, Vol. 15, 1953, pp. 235-250.

[10] P. O. Astrand and I. Rhyming, "A Nomogram For Calculating of Aerobic Capacity (Physical Fitness) From Pulse Rate During Submaximal Work", Journal of Applied Physiology, Vol. 7, No. 2, 1954, pp. 218-221.

There is no evidence to indicate age associated changes in heart rate values during submaximal work tests. I. Astrand stated that fitness decreases with increasing age[11] but she went on to say that "there is no doubt that young people can reach a higher heart rate level than old people, at least when performing such types of work as bicycling and running."[12] Bicycling and running are considered maximal work tests.

In an earlier paper I. Astrand reported the work of Von Dobeln, Engstron and Strom in which they found the pulse reaction to submaximal work among airplane pilots between twenty and fifty years of age to be completely independent of age.[13] This was substantiated by Astrand's own work in which she found no significant differences in pulse rate between a group of older subjects and a group of younger athletes in going from the resting level to the steady state.

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[11] Irma Astrand, "Aerobic Work Capacity in Men and Women with Special Reference to Age", Acta Physiologica Scandinavica, Vol. 49, Supplementum 169, 1960, p. 80.

[12] Ibid., p. 24.

[13] Irma Astrand, "The Physical Work Capacity of Workers 50-64 Years Old", Acta Physiologica Scandinavica, Vol. 42, 1958, p. 84.

Simonson supports the view that age is of no consequence in submaximal work.[14] He postulated that older men perform work at this level as efficiently as younger men. In his study of adult men the pulse rate increase was about the same for twenty-five men with a mean age of 33.3 and eleven men with a mean age of 53. Simonson hypothesized that lower maximal pulse rates in older men resulted from an inability or unwillingness to exert themselves as much as younger men.

Heart Rate Values and Prior Physical Activity

Prior physical activity can be a period of formal physical training or it can be the spontaneous activity found to a greater or lesser extent in every person's daily life. I. Astrand stated that training caused a decreased resting heart rate, a reduction in pulse rate during submaximal work but no change in the maximum pulse rate during maximal work.[15]

An explanation for the increased efficiency of the hearts of trained individuals is given by Brouha.[16] He stated

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[14]Ernst Simonson, "Physical Fitness and Work Capacity of Older Men", Geriatrics, Vol. 2, No. 1, 1947, p. 116.

[15]P. O. Astrand, "Human Physical Fitness With Special Reference to Sex and Age", Physiological Review, Vol. 36, 1956, p. 322.

[16]Lucien Brouha, "Training", in Science and Medicine of Exercise and Sports, edited by Warren R. Johnson (New York: Harper and Brothers) 1960. p. .

that training enables the heart to become more efficient by circulating more blood while beating less frequently. This is the result of an increased stroke volume. He further stated that for a standard amount of work the heart rate will decrease as training progresses, and that this slowing process is present during rest, work, and recovery. In an earlier paper Brouha and his associates stated that while training increases the efficiency of the body, each man has a maximum efficiency which can be developed through regular and adequate training; but, regardless of the severity of the training, no man can exceed his constitutionally possessed physical efficiency potential.[17]

Bock, Vancaulaert, Dill, Folling and Hurxthal stated that "Training enables the organism to maintain an internal environment approaching that of the normal resting state even during severe work".[13] Substantiation of this view is present in the following studies.

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[17]Lucien Brouha, Norman M. Fradd, and Beatrice M. Savage, "Studies in Physical Efficiency of College Students", Research Quarterly, Vol. 15, 1944, p. 224.

[13]A. V. Bock, C. Vancaulaert, D. B. Dill, A. Folling, and L. M. Hurxthal, "Studies in Muscular Activity III, Dynamical Changes Occurring in Man At Work", Journal of Physiology, Vol. 66, 1928, p. 159.

A study conducted by Arbeits, Jokle and Koskela to determine the effects of a thirty day physical training period on the heart of a forty year old previously untrained man showed a decrease in the resting pulse of the subject from 105 beats per minute before training to 65 beats per minute at the end of the thirty days.[19]

Cogswell, Henderson and Berryman studied seven male volunteers 23-23 years of age and tested them over a period of three months.[20] Submaximal work (The Harvard Step Test) was administered three times per week and pulse rates were taken one, two and three minutes before and after the test. This work load resulted in a decreased heart rate with increased training. There was no decrease in resting pulse rates.

Both of the above studies involved untrained individuals and they give no indication as to the prolonged effects of the training, if any. Montoye, Collins, and Stauffer did a study on varsity basketball players to determine the effects

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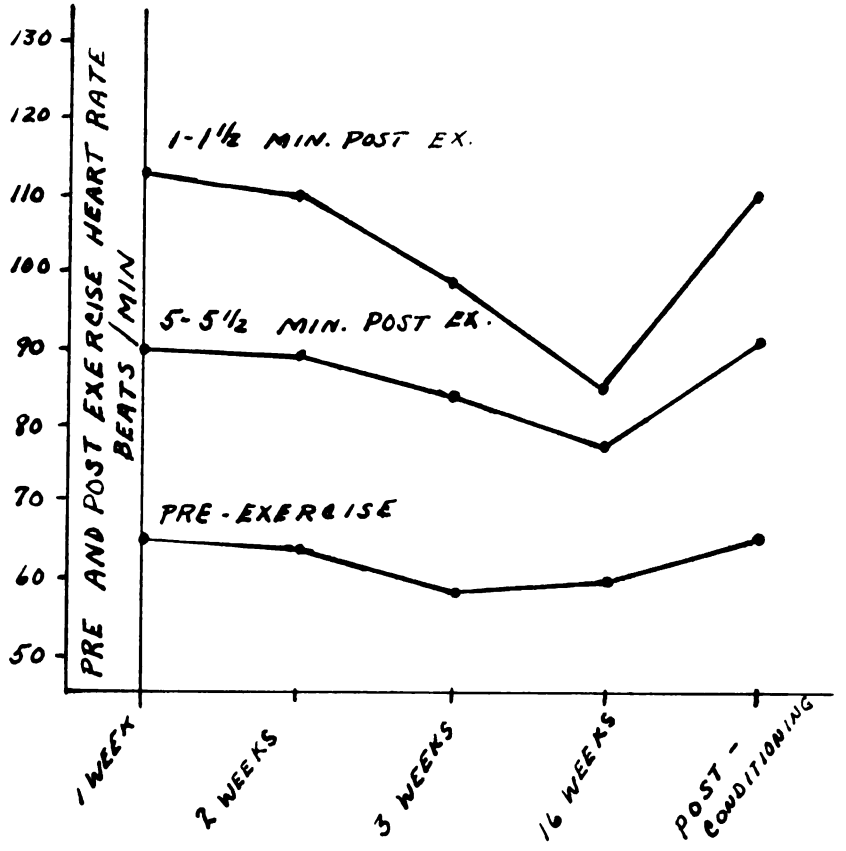
[19]S. R. Arbeits, E. Jokle, A. Koskela and W. E. McCubbin, "Ballistocardiographic Changes During a 30 Day Physical Training Period", American Heart Journal, Vol. 54, 1957, p. 557.

[20]Robert C. Cogswell, Charles R. Henderson and George R. Berryman, "Some Observations on the Effects of Training on Pulse Rate, Blood Pressure and Endurance in Humans Using the Step Test (Harvard), Treadmill and Electrodynamic Brake Bicycle Ergometer", American Journal of Physiology, Vol. 146, 1946, pp. 423-429.

of a formal training season on athletes "out of training".[21] The study began prior to the basketball season and the subjects should be considered as athletes "out of training" at the beginning of the test. The subjects were tested twice prior to the beginning of the training season, twice during the training season and once, one month after the end of the basketball season. Each testing situation involved use of the Harvard Step Test. The following results were obtained.



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[21] H. J. Montoye, W. Dayne Collins and Gordon Stauffer, "Effects of Conditioning on the Ballistocardiogram of College Basketball Players", Journal of Applied Physiology, Vol. 15, 1960, p. 450.

It can be seen from the chart above that resting pulse rates were affected least by the training season. The post-exercise rates were affected rather dramatically but in all three cases the pulse rates returned very nearly to the pre-training level within one month after the end of the training season. This study leads to the conclusion that training does not have a prolonged irreversible effect on pulse rate.

One further study conducted in this area by Damez, Dawson, Mathis, and Murray showed that teenagers actively engaged in athletic sports had lower resting pulses, lower pulse rates after exercise and a quicker return to normal than did teenage girls not actively engaged in sports.[22]

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[22] Marie Damez, Percy M. Dawson, Dorothy Mathis and Margaret Murray, "Cardiovascular Reactions in Athletic and Non-Athletic Girls", Journal of the American Medical Association, Vol. 86, No. 19, 1925, p. 22.

CHAPTER III

METHODOLOGY

Data were collected from January through April, 1962. All measures were completed in two testing periods of approximately one hour each. The first period was devoted to the collection of data on social status and level of activity in daily life. At this time each subject was given a trial on the treadmill to familiarize her with the procedure. The second testing period was devoted to the collection of data on anthropometric measures and heart rate measures.

Subjects

The subject group was composed of forty women between the ages of 30-50 years with ten women in each five year age group. No attempt was made to get an equal distribution of ages within each five year group. All subjects volunteered for the test. Each subject was given a medical approval from a physician stating that the individual was sufficiently healthy to participate in the test.

Social status was determined by using the Index of Social Status--Short Form devised by McGuire and White.[1]

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[1]Carson McGuire and George D. White, "The Measurement of Social Status", Research Paper in Human Development No. 3 (revised), Department of Educational Psychology, The University of Texas, March, 1955.

The classification is derived by rating the individual's husband's occupation, source of income, and education. The individuals are rated on a scale including Lower Lower Class (LL), Upper Lower Class (UL), Lower Middle Class (LM), Upper Middle Class (UM), and Upper Class (UC). In the case of single women the occupation, source of income and education of the woman involved was used.

The level of physical activity was ascertained by a questionnaire in which the subject was asked to recall her participation in sport, gardening, home maintenance and improvement, homemaking, and community activities over the twelve month period prior to the test. This information, along with the size and composition of their family and their occupation, if any, was used to rate the activity level of each individual. Each subject was rated on a four level scale of light (L), moderately active (MA), active (A), or very active (VA). Each subject was given two ratings: a combined homemaking plus occupational index and a leisure time index.

The ratings were derived subjectively by use of appropriate energy cost tables for estimating the caloric output required by various activities. The occupational

rating was obtained from the Estimates of Worker Trait Requirements for 4,000 Jobs as Defined in the Dictionary of Occupational Titles, U. S. Department of Labor. The combined homemaking plus occupational rating was determined by assigning the individual the highest rating obtained in either classification.

Anthropometric Measures

Height was taken without shoes. The subject stood with her back against the calibration on the stadiometer; heels, hips, shoulders and head were touching the backboard. With the subject standing erect a square was placed firmly against the top of the subject's head and the back of the stadiometer. The reading was taken at the lower edge of the square with height being recorded to the nearest one-half centimeter.

The subjects were weighed without shoes and with lightweight clothing of shorts or slacks, blouse, socks, and undergarments (approximately 2-3 pounds). Weight was recorded to the nearest one-hundredth kilogram.

Pubic skinfold was measured with a Lange Skinfold Caliper[3] calibrated to exert a pressure of 10 gr. per square

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[3]Werna-Gren Aeronautical Research Laboratory, Kentucky Research Foundation, University of Kentucky, Lexington, Kentucky.

millimeter of jaw surface. The measure was obtained by grasping the skinfold between the thumb and index finger at a sufficient depth to include two thicknesses of skin and subcutaneous fat but no muscle. The measurement was taken on the right side of the body in the vertical plane with the subject lying in a supine position on a flat surface with her hands at her sides and all clothing removed from the area. The Lange Calipers were applied approximately one centimeter from the fingers at a depth equal to the thickness of the fold. Three successive measurements were taken at the site.

Per Cent Standard Weight, Predicted Specific Gravity and Fat Free Body Weight

Per cent standard weight was calculated by dividing the individuals predicted weight into the actual weight. Predicted weights were obtained from the Build and Blood Pressure Study.[4] The standard weight figures in the Build and Blood Pressure Study included shoe heel height of about two inches and usual indoor clothing, which for women

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[4] Build and Blood Pressure Study, 1959, (Chicago: Society of Actuaries) as reported by Millicent L. Hathaway and Elsie D. Foard in Heights and Weights of Adults in the United States, Home Economics Research Report #10, Agricultural Research Service (United States Department of Agriculture, Washington, D. C., August, 1960, p. 11.

approximated four to six pounds. In order to make the heights and weights in this study comparable to those in the Build and Blood Pressure Study, two inches were added to each height and three pounds to the weight of each subject.

Predicted specific gravity was determined by use of the prediction formula devised by Young, Martine, Tensuan, and Blondin.[5]

Fat Free Body Weight or lean body mass was calculated by the Matthews and Pace formula:

Fat free body weight = weight in kilograms - kilograms of fat

Kilograms of fat = per cent fat x weight in kilograms

and per cent fat = 100 $\left(\frac{5.548}{\text{specific gravity}} - 5.044\right)$.[6]

Submaximal Work Test And

Collection of Heart Rate Data

The step test involved use of a wooden platform eight inches high. Each subject stepped up and down at a rate of 24 full repetitions per minute for three minutes.

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[5] Young, Charlotte, Elizabeth Martine, K. Tensuan, and Jean Blondin, "Predicting Specific Gravity and Body Fatness in Young Women", [illegible] Vol. 40, February, 1952, p. 105.

[6] Pace, N., and Rathbun, E. N., "Studies on Body Composition. 3. The Body Water and Chemically Combined Nitrogen Content in Relation to Fat Content", Journal of Biological Chemistry, Vol. 158, 1945, p. 685.

Each subject was fitted with three electrodes (one EKG lead) used to pick up electrical impulses of the heart before, during and after exercise. One was placed on the left side of the chest two inches from the sternum and three to four inches below the left clavicle. A second was placed on the left side of the back approximately two inches to the left of the sixth cervical vertebrae. The third electrode (ground) was located on the left side of the lower back, one to two inches to the left of the ninth thoracic vertebrae.

The skin directly in the area of electrode placement was first rubbed with Cramer's Tufskin. The electrode was then coated with a light covering of electrode paste and fastened into place with Elastoplast, an elastic stretch bandage, and adhesive tape. The subject was seated in a chair for a recording of a resting heart rate. All recording was done on a Sanborn Twin-Viso recorder. The resting heart rate was taken for sixty seconds. After this the subject was given a demonstration of the procedure to be followed in the step test as well as an opportunity to familiarize herself with the designated speed of stepping. Each subject was instructed to follow the speed of an electronic metronome calibrated to twenty-four full repetitions or ninety-six beats per minute and was told to proceed in the following manner:

1. Start by placing either your right or left foot on the step.
2. Next place the other foot on the step.
3. Remove the first foot from the step to the floor.
4. Remove the second foot from the step to the floor.
5. Continue in a like manner until you are instructed to stop..

Immediately upon completion of the three minutes of stepping the individual was seated and a recording was made during an eight minute recovery period. Recordings of the heart rate were made during one minute of resting; the first minute of exercise, the first fifteen seconds of each consequent minute of exercise; the first minute of recovery, and the first fifteen seconds of each consequent minute of the eight minute recovery period.

CHAPTER IV

ANALYSIS OF DATA

Subjects

The social status rating of the four groups is shown in Table I. The social status of all subjects tested ranged from upper lower to upper class with 60 per cent of the subjects falling in the upper middle class and 22.5 per cent in the lower middle class.

TABLE I

SOCIAL STATUS RATING OF SUBJECTS IN FOUR AGE GROUPS

AGE	UC	UM	LM	UL	LL
30-35	1	8	1		
35-40	2	5	2	1	
40-45		6	4		
45-50	1	5	2	2	
TOTALS	4	24	9	3	

The means, standard deviations, medians and ranges of age, height, weight, per cent of standard weight, pubic skinfold, per cent of fat of body weight, predicted specific

TABLE II

MEANS, STANDARD DEVIATIONS, MEDIANS, AND RANGES OF ANTHROPOMETRIC MEASURES FOR THE FOUR AGE GROUPS

Measure	Mean	Standard Deviation	Median	Range
AGE (Years-months)	32-2	1-5.2	31-9.5	30-5 to 34-11
HEIGHT (Cm.)	165.95	6.09	166.75	157.00 - 175.50
WEIGHT (Kg.)	58.03	5.83	57.13	51.68 - 69.18
PER CENT STD. WGT.(%)	93.03	5.83	90.48	87.41 - 104.87
PUBIC SKINFOLD (Mm)	32.05	11.60	31.00	17.50 - 55.00
PER CENT FAT (%)	27.39	2.67	26.89	24.76 - 33.91
PREDICTED SPEC. GRAV.	1.043	.0162	1.044	1.031- 1.048
FAT FREE BODY WT. (Kg.)	42.05	3.33	41.45	37.83 - 48.31
AGE (Years-months)	37-7	1-5.3	37-3.5	35-7 to 39-10
HEIGHT	166.70	6.34	167.75	156.00 - 176.50
WEIGHT	62.53	10.13	59.62	52.30 - 80.54
PER CENT STD. WGT.	99.39	7.27	94.10	81.33 - 124.77
PUBIC SKINFOLD	32.10	11.30	29.50	12.50 - 47.00
PER CENT FAT	28.57	4.35	28.60	21.79 - 36.29
PREDICTED SPEC. GRAV.	1.041	.0269	1.041	1.026- 1.054
FAT FREE BODY WGT.	44.35	5.06	42.90	38.47 - 51.93

TABLE II (Cont'd.)

Measure	Mean	Std. Dev.	Median	Range
AGE	43-2	1-7.8	43-9.5	40-0 - 44.10
HEIGHT	164.25	7.94	162.75	156.00 - 170.00
WEIGHT	60.73	8.63	58.43	50.20 - 72.30
PER CENT STD. WGT.	93.18	10.02	92.14	78.88 - 105.33
PUBIC SKINFOLD	32.35	12.80	34.50	12.00 - 48.50
PER CENT FAT	27.54	4.17	26.45	21.13 - 33.01
PREDICTED SPEC. GRAV.	1.043	.0260	1.045	1.032- 1.056
FAT FREE BODY WGT.	43.77	4.79	42.40	37.39 - 51.40
AGE	46-11	1-7.3	46-5.5	45-1 - 40-8
HEIGHT	162.65	8.70	161.25	150.00 - 175.00
WEIGHT	53.26	8.37	53.96	43.94 - 71.86
PER CENT STD. WGT.	91.36	9.93	88.51	77.96 - 107.83
PUBIC SKINFOLD	30.80	7.65	31.25	17.50 - 42.00
PER CENT FAT	26.94	2.68	26.82	21.73 - 31.56
PREDICTED SPEC. GRAV.	1.044	.0164	1.044	1.035- 1.054
FAT FREE BODY WGT.	42.45	5.47	43.00	34.40 - 51.52

gravity, and fat free body weight for each of the four age groups are shown in Table II.

The mean ages of the four groups were 32 years, 2 months; 37-7, 43-2, and 46-11. The 45-50 year age group had the lowest mean height of any group with a mean height of 162.65 centimeters. The greatest mean height was 166.70 centimeters in the 35-40 year age group.

The mean weight of each group ranged from 58.03 kilograms for the 35-40 year olds. The subjects between the ages of 40-45 years had a mean weight of 60.73 kilograms and the subjects between 45-50 years had a mean weight of 58.26 kilograms. The 35-40 year olds had the greatest mean per cent of standard weight with 96.77 per cent while the lowest mean per cent of standard weight was 88.18 in the 45-50 year old group. Per cents of standard weight for the other two groups were: 30-35, 90.76%; 40-45, 90.53%. It is interesting to note that all groups had mean per cents of standard weight less than the normal 100%. A total of thirty-two subjects had per cents of standard weight less than 100 per cent. This would seem to indicate that subjects volunteering for a physical fitness study tend to be underweight when compared with the population at large.

Individual pubic skinfold measurements ranged from 12.00 to 55.00 millimeters for all subjects while the mean pubic skinfold measures for each group ranged from 30.30 to 32.35 millimeters. It was expected that the range between the four groups would be quite small. It was expected, however, that the older subjects would have the largest pubic skinfold measures, but they were found to have the smallest mean pubic skinfold measures of any group. The greatest mean pubic skinfold thickness was in the 40-45 year old group.

In addition to having the greatest mean height, weight, and per cent of standard weight, the 35-40 year olds also had the largest mean per cent of fat of body weight with 28.57 per cent. The range in mean per cent of body fat was 26.94 per cent to 28.57 per cent, a difference of only 1.63 percentage points.

Mean predicted specific gravity values were highest for the 45-50 year age group with a mean predicted specific gravity of 1.044. This value was only .001 higher than the mean predicted specific gravity of the 30-35 year age group and the 40-45 year age group and was .003 higher than the predicted specific gravity of the 35-40 year age group.

The 35-40 year age group had the highest mean kilograms of fat free body weight (lean body mass) of any of the four groups. The least mean kilograms of fat free body weight was in the 30-35 year olds.

Table III gives a summary of the highest and lowest mean values for the various anthropometric measures.

TABLE III

AGE GROUP IN WHICH THE HIGHEST AND LOWEST MEAN VALUES FOR THE VARIOUS ANTHROPOMETRIC MEASURES WERE FOUND

MEASURE	HIGHEST MEAN VALUE	LOWEST MEAN VALUE
Height (Cm.)	35-40	45-50
Weight (Kg.)	35-40	30-35
Per Cent Standard Weight (%)	35-40	45-50
Pubic Skinfold (Mm.)	40-45	45-50
Per Cent Fat (%)	35-40	45-50
Predicted Specific Gravity	45-50	35-40
Fat Free Body Weight (Kg.)	35-40	30-35

Heart Rate Values and Age Associated Changes

Heart rate values during work

The means, medians and ranges of the heart rates at rest and during work and recovery for the different age groups are shown in Table IV. Graphical presentation of the mean heart rates during work and recovery may be found in Figure 1. A similar pattern of increase and decrease in the mean heart rate for all age groups throughout the entire time period can be seen in this figure. The mean heart rate of the 30-35 year age group increased 55 beats or 66 per cent from rest to the end of the third minute recording of exercise. During this same time there was an increase of 50 beats or 61 per cent for the 35-40 year age group, 50 beats or 61 per cent for the 40-45 year age group and 51 beats or 64 per cent for the 45-50 year age group. The range of mean resting heart rates of the four groups was 3.4 beats per minute while the range of mean heart rates during the third minute of the step test was 7.6 beats per minute.

Correlation between age and maximum heart rate of the subjects in this study was essentially zero. In this study the results seem to indicate that the older individuals were more sluggish in their response to the exercise test and thus showed the lowest mean heart rates during work.

TABLE IV

MEANS, MEDIANS AND RANGES AT REST AND DURING WORK AND RECOVERY FOR ALL AGE GROUPS

Age Group	Resting $\bar{X}$	Resting M*	Resting R*	0-15 Sec. $\bar{X}$	0-15 Sec. M	0-15 Sec. R	15-30 Sec. $\bar{X}$	15-30 Sec. M	15-30 Sec. R	30-45 Sec. $\bar{X}$	30-45 Sec. M	30-45 Sec. R
30-34	83.4	83.0	60-114	106.4	103	82-124	115.0	114.5	91-142	121.2	120.0	103-153
35-39	81.9	80.5	70-94	104.0	105	90-126	109.9	107.0	99-130	114.3	111.0	102-135
40-44	82.0	84.5	65-96	104.6	103	74-134	111.9	110.0	83-140	117.6	114.5	94-143
45-49	80.0	82.0	61-100	103.6	101	85-117	105.4	104.0	92-127	111.2	112.5	93-132

*M, Median; R, Range.

EXERCISE

	45-60 Sec. $\bar{X}$	45-60 Sec. M	45-60 Sec. R	1'-1'15" $\bar{X}$	1'-1'15" M	1'-1'15" R	2'-2'15" $\bar{X}$	2'-2'15" M	2'-2'15" R
30-34	125.4	123.0	100-155	131.0	123.0	113-161	138.4	133.5	119-167
35-39	120.3	117.5	106-142	124.9	122.0	111-149	131.8	127.5	119-157
40-44	121.4	119.0	93-154	124.6	120.5	99-161	131.6	130.5	104-178
45-49	116.4	117.0	100-136	121.2	121.5	104-140	130.8	133.0	113-148

EXERCISE

TABLE IV (Cont'd)

Age Group	$\bar{X}$	M*	R*	$\bar{X}$	M	R	$\bar{X}$	M	R	$\bar{X}$	M	R
			98-			80-			79-			72-
30-34	125.5	126.5	152	111.3	115.5	130	104.2	107.0	123	96.8	93	124
			114-			94-			83-			77-
35-39	126.0	120.0	154	112.3	103.5	138	105.1	103.0	129	98.9	97	123
			93-			93-			74-			74-
40-44	121.2	119.0	165	110.3	106.0	146	102.5	97.5	140	97.3	91.5	138
			100-			85-			83-			76-
45-49	122,5	123.0	138	110.2	111.0	131	101.8	100.0	122	95.8	95.5	113
		0-15 Sec.			15-30 Sec.			30-45 Sec.			45-60Sec.	

M, Median; R, Range.

RECOVERY

			71-			67-			68-			65-
30-34	93.1	96.5	116	91.5	95.0	107	87.3	91.0	102	89.2	91.5	105
			73-			67-			67-			70-
35-39	95.6	95.0	120	90.9	89.5	122	90.2	87.5	120	89.1	84.0	116
			67-			59-			61-			59-
40-44	93.2	98.5	123	87.9	83.5	130	87.3	83.5	120	83.8	84.0	108
			73-			66-			64-			67-
45-49	91.9	90.5	117	86.1	80.5	111	85.9	83.5	105	85.2	82.0	104
		1-1'15"			2'-2'15"			3'-3'15"			4'4'15"	

RECOVERY

			69-			66-			64-
30-34	89.3	90.5	105	85.3	87.0	98	85.4	92.0	98
			71-			73-			72-
35-39	89.4	91.0	108	86.5	83.5	102	88.4	86.0	101
			62-			63-			60-
40-44	88.5	89.5	112	85.7	85.0	110	87.0	87.0	105
			67-			67-			64-
45-49	82.9	84.0	100	82.9	81.0	101	82.2	83.0	104
		5'-5'15"			6'-6'15"			7'-7'15"	

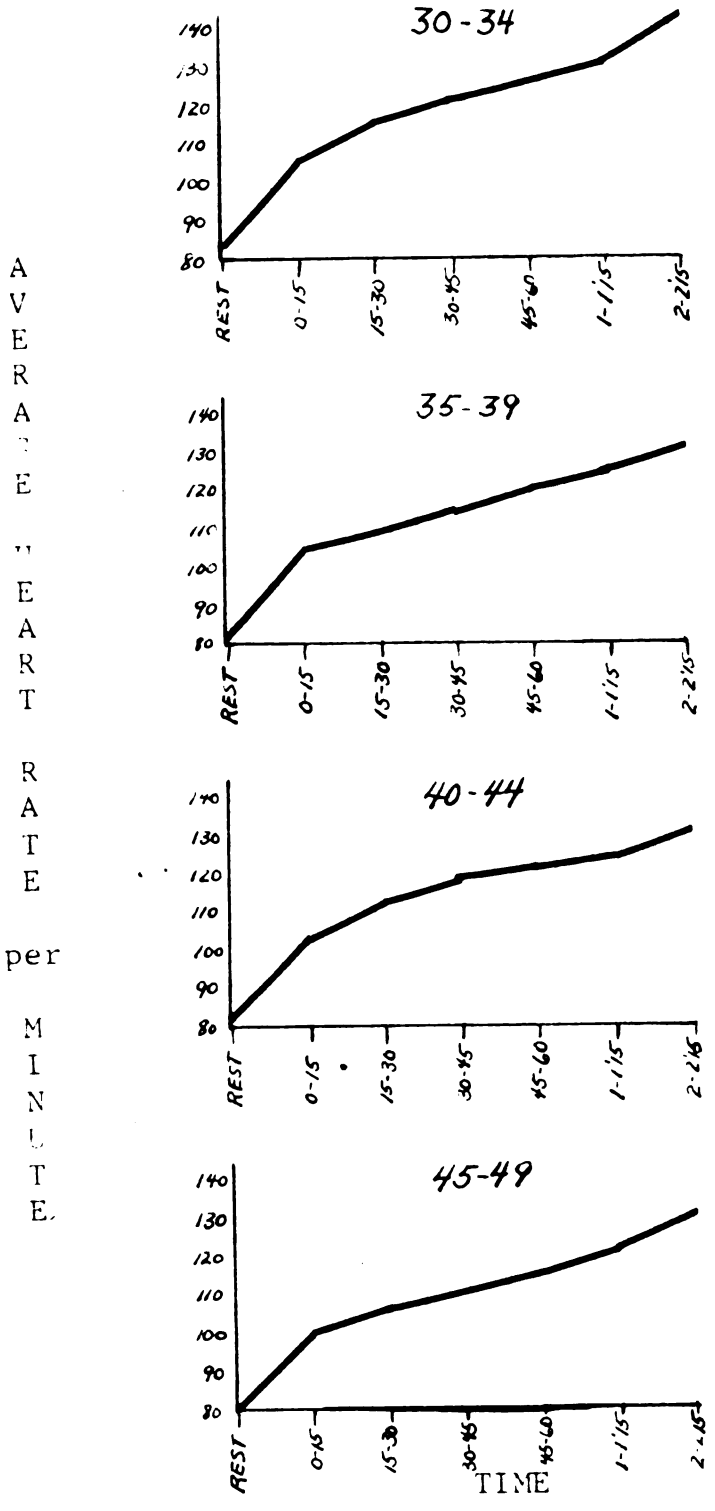


FIGURE 1

RESTING AND EXERCISE HEART RATES
FOR FOUR AGE GROUPS

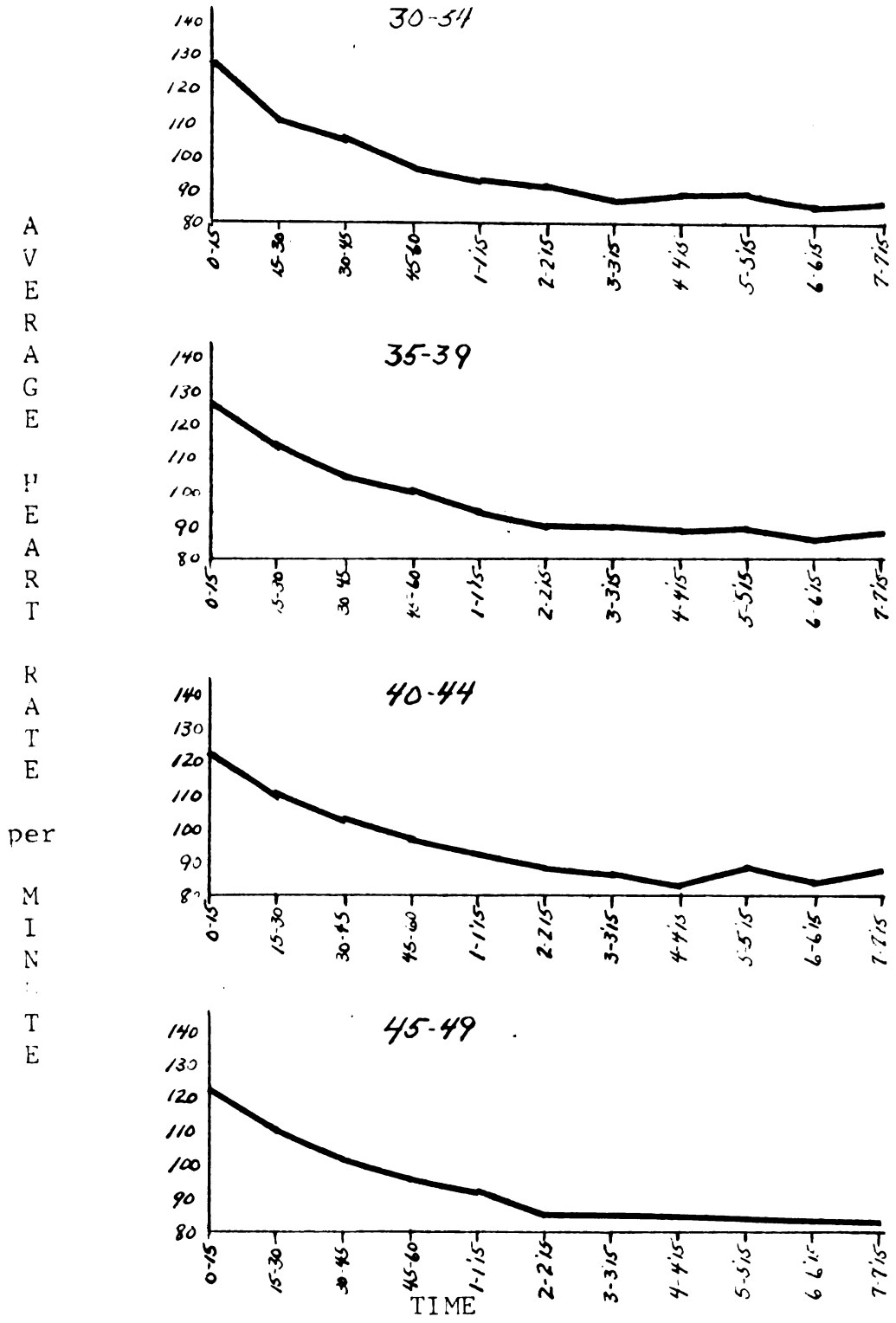


FIGURE 1

RECOVERY HEART RATES FOR
FOUR AGE GROUPS

Other research studies in this area have reported that there is a lowering in the maximal heart rate with increasing age but that decrease in the maximal heart rate with ageing is only evident in maximal work. Previous workers have found that age per se has no effect on the heart rate during exercise of light or moderate loads; the exercise used in this study would be considered a light to moderate work load.

Within the four age groups the maximal heart rates of the individuals vary widely. Figure 2 shows the per cent of the total of each group which reached various maximum heart rates during exercise. Sixty per cent of the 30-35 year olds reached maximum heart rates of 130-150 with 40 per cent having maximum heart rates of 130-140. In the 35-40 year age group 50 per cent had maximum heart rates of 120-130. The subjects in the 40-45 year age group had more varying maximum heart rates than any of the other groups with 30 per cent falling in the 110-120 category, 20 per cent in the 130-140 category and 10 per cent in each of the following: 100-110, 120-130, 140-150, 150-160, and 170-180. Within the 45-50 year olds 30 per cent of the subjects had maximum heart rates of 140-150. The 45-50 year age group had the smallest range of maximum heart rates of any of the groups with all subjects falling between 110-150 beats per minute.

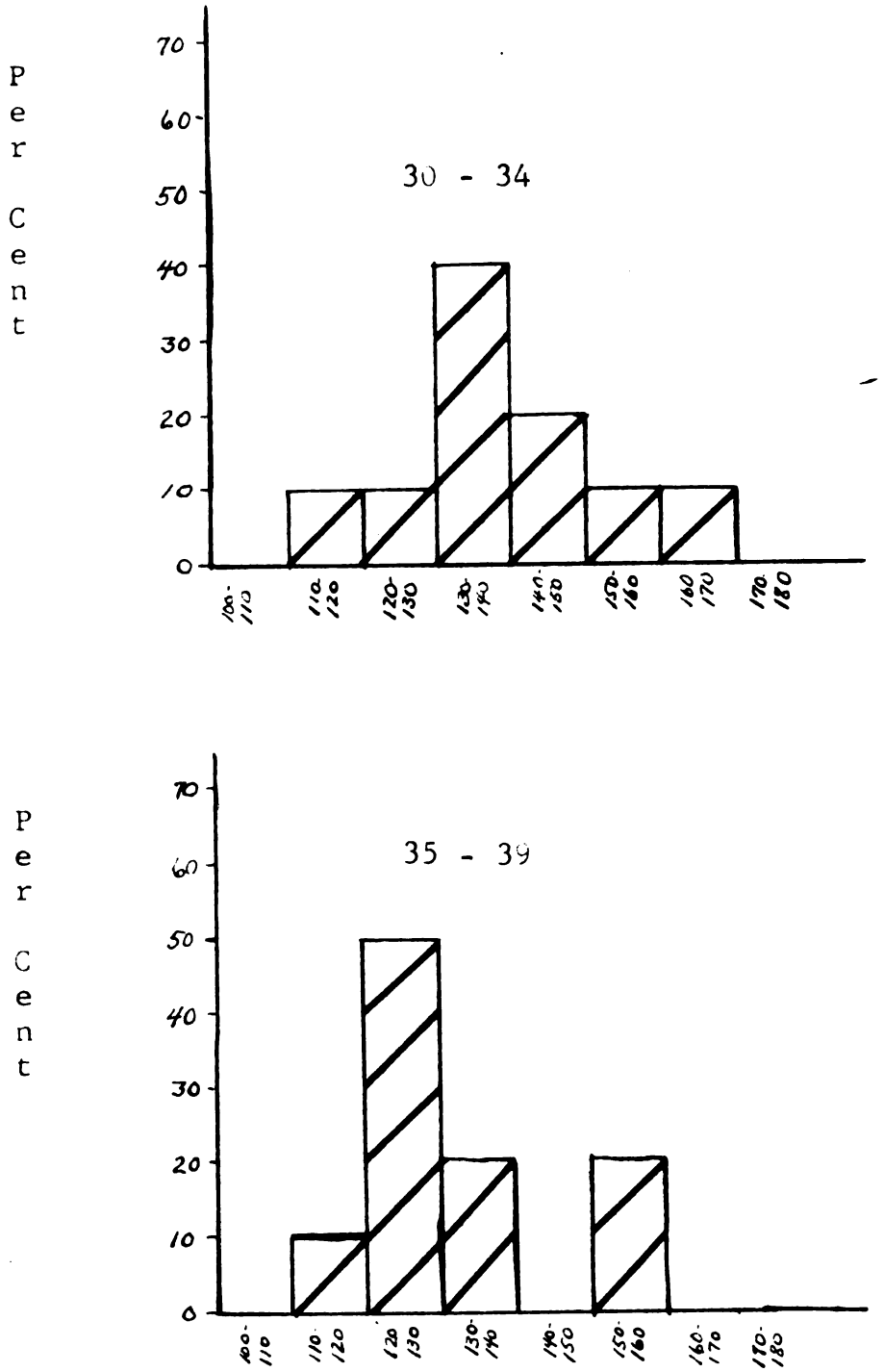


FIGURE 2.

PERCENTAGE OF SUBJECTS REACHING VARIOUS MAXIMUM HEART RATE DURING WORK

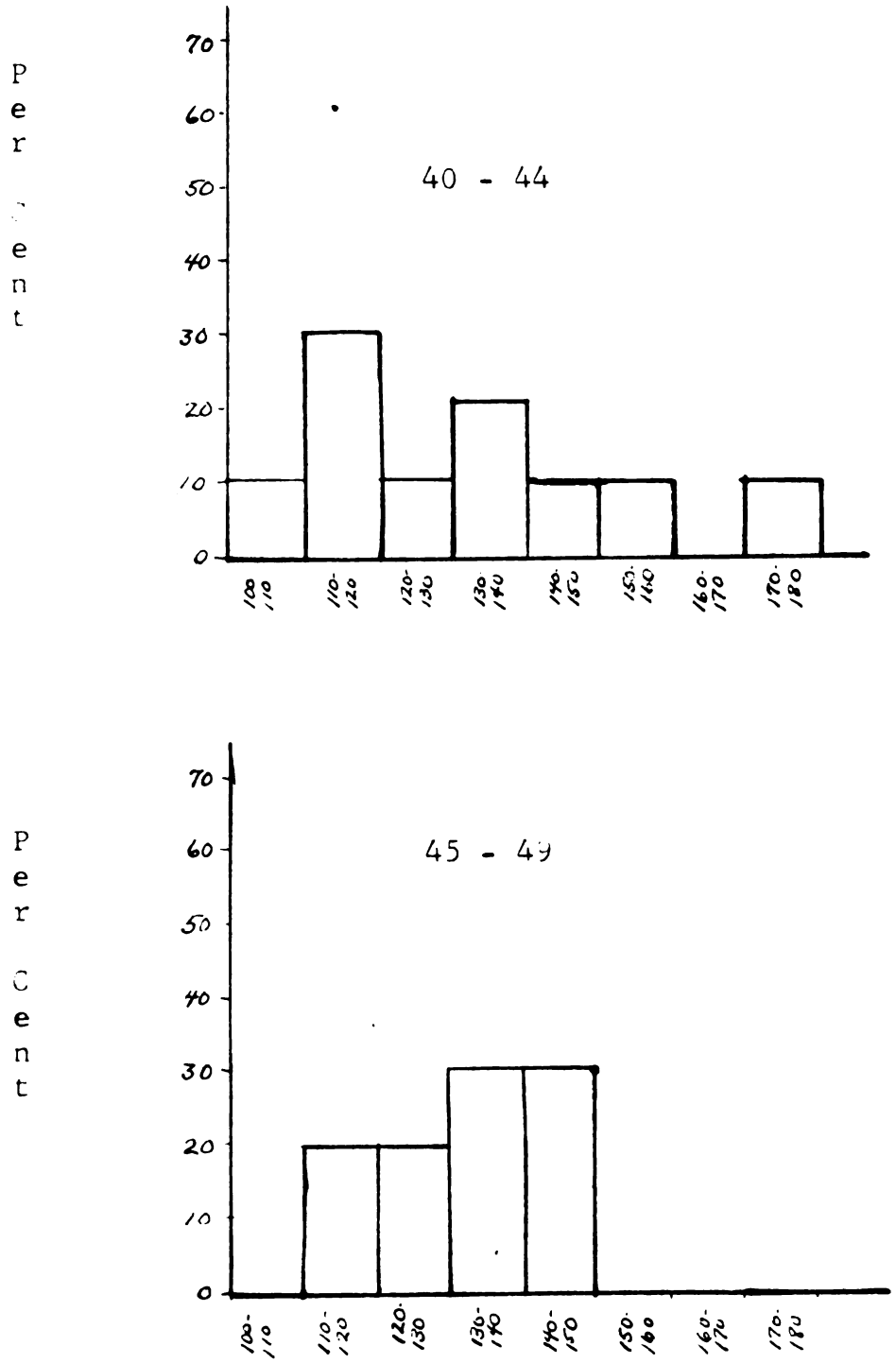


FIGURE 2

PERCENTAGE OF SUBJECTS REACHING VARIOUS MAXIMUM HEART RATE DURING WORK

Heart values during recovery

Referring to Darling's definition of fitness, we note that fitness involves the ability to return to normal as well as the ability to maintain the normal state. Recovery is an equally important part of the whole problem. It should be emphasized that the quickness of recovery of the heart rate after exercise is a valid measure of fitness.

Figure 3 shows the total number of subjects in each age group returning to within six beats of their resting heart rates within the eight minute recovery period. Seven subjects in the 30-35 year age group and seven in the 35-40 year age group returned to this level. There were eight subjects who returned to within six beats of resting in the 40-45 year age group and the 45-50 year age group had six subjects returning to this level.

Total recovery for three subjects came within the first minute of recovery. These three subjects had a mean resting heart rate of 90 beats per minute as compared with a mean resting heart rate of 82 beats per minute for the other thirty-seven subjects. At some point during the eight minute recovery period these same three subjects had recovery rates

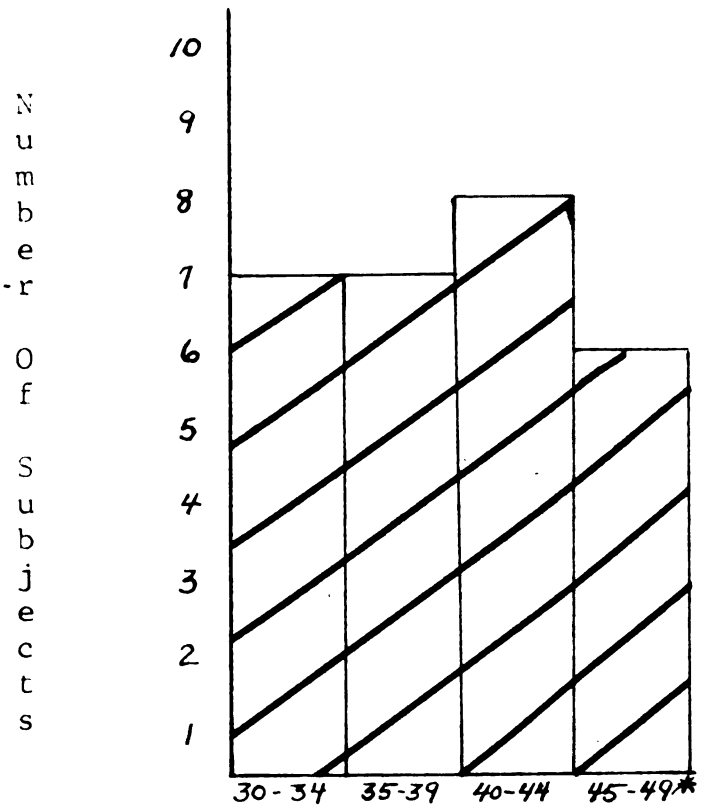


FIGURE 3

NUMBER OF SUBJECTS RECOVERING TO WITHIN SIX BEATS OF RESTING HEART RATE WITHIN 8 MINUTE RECOVERY PERIOD

* In addition, 1 subject recovered to within 9 beats during a shortened 6 minute recovery period.

of 20, 16, and 7 beats per minute below their resting pulses. Another fifteen subjects in the total group had heart rates at some point in the recovery period that were lower than their resting pulses. It must be concluded that the resting pulses in many cases were affected to some degree by psychic factors such as the newness of the testing situation.

The average mean heart rates one minute after exercise as compared to mean maximum rates for each group are shown in Figure 4. The 30-35 year age group had the greatest percentage recovery after one minute, dropping from a mean maximum heart rate of 138.8 beats per minute to a mean heart rate of 93.1 beats per minute after one minute of recovery. This amounted to a thirty-three per cent drop in heart rate. The next highest percentage drop was thirty per cent in the 45-50 year age group. The 35-40 year age group dropped twenty-eight per cent and the 40-45 year age group dropped twenty-nine per cent after one minute of recovery.

In addition to having the greatest percentage drop the 30-35 year age group had mean heart rates one minute after exercise of only twelve per cent over resting rates. This group exhibited the greatest recovery of any group at this point. The per cent over resting for the other groups at this same time interval was: 35-40, seventeen per cent; 40-45, fourteen per cent; and 45-50, fifteen per cent.

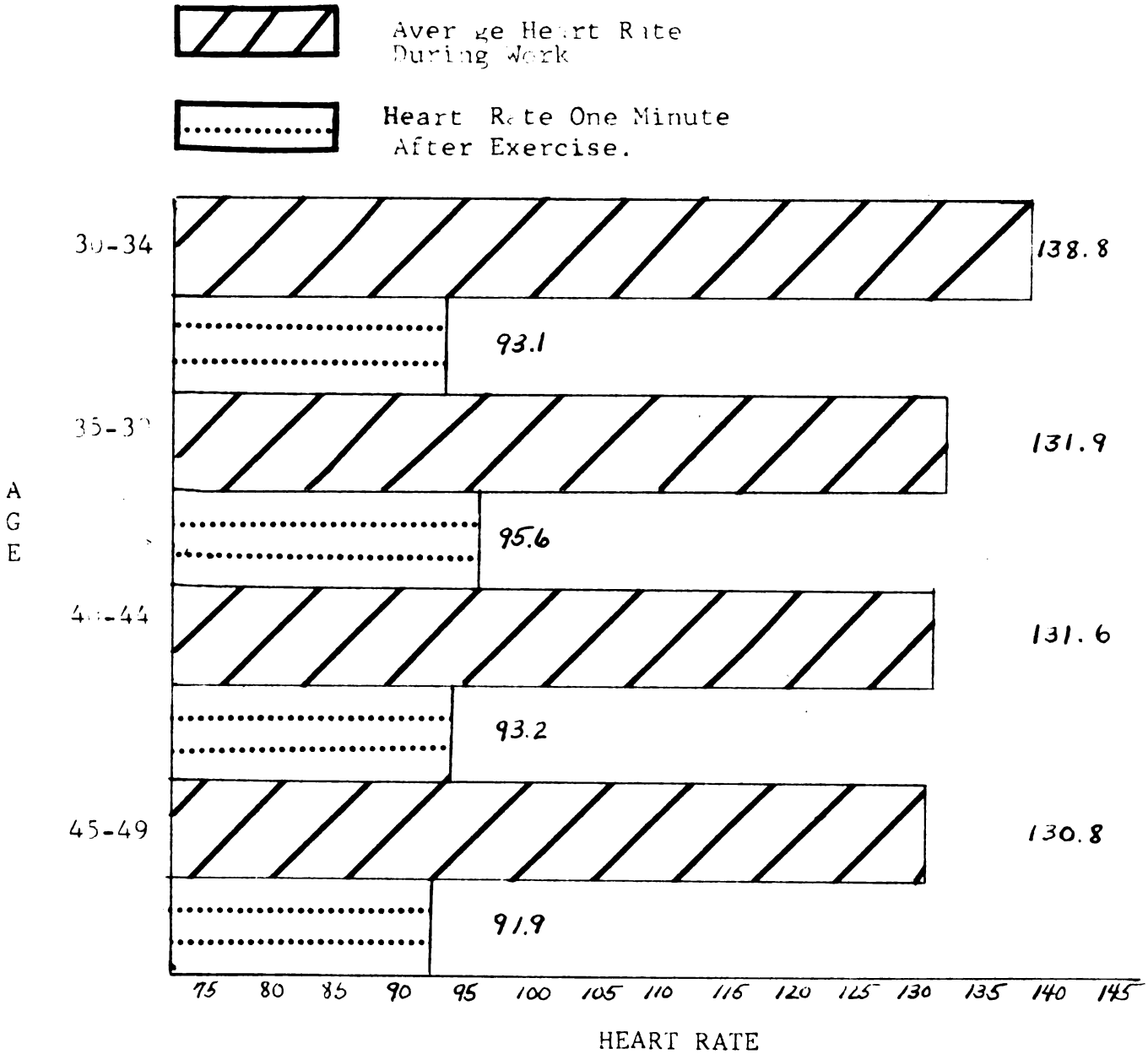


FIGURE 4

MEAN MAXIMAL HEART RATE DURING WORK AND HEART RATE ONE MINUTE AFTER EXERCISE FOR EACH AGE GROUP

This difference changes somewhat by the end of the eight minute recovery period. At that time interval the 30-35 year olds still had the best recovery with a mean heart rate of only two per cent over their mean resting rate. The 35-40 year olds were eight per cent over mean resting rates at this time; the 40-45 year olds six per cent over mean resting rates and the 45-50 year olds three per cent over mean resting rates. It would seem that the younger subjects recovered much faster than the other age groups and that there is little difference in recovery rate between the other three age groups.

Heart Rate Values and Physical Activity

It should be noted that only a minor parallel is suggested between "level of activity" and a "formal training program". Because of the effect of physical training on heart rate values a physical activity recall record was taken on each subject.

The two indices of level of activity compiled for each age group are given in Tables V and VI. The 30-35 year olds appear to be the most active group in terms of homemaking activities with seven of ten rated as active or very active. The 45-50 year olds were the least active in homemaking with four rated as light and three as moderately active. This is primarily a result of the older age group having less children.

TABLE V

HOMEMAKING, OCCUPATIONAL, ACTIVITY
RATING BY AGE GROUPS

AGE	LIGHT	MODERATELY ACTIVE	ACTIVE	VERY ACTIVE
30-34	1	2	5	2
35-39	2	5	1	2
40-44	1	4	2	3
45-49	4	3	2	1
TOTALS	8	14	10	8

TABLE VI

LEISURE ACTIVITY RATING
BY AGE GROUPS

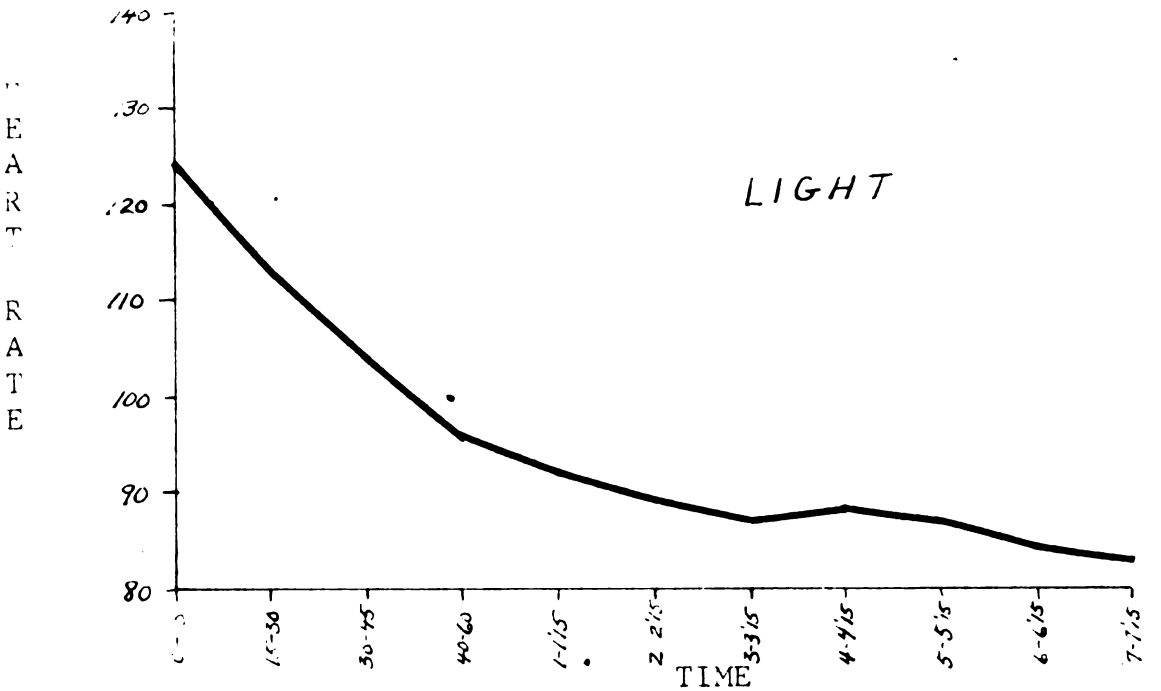
AGE	LIGHT	MODERATELY ACTIVE	ACTIVE	VERY ACTIVE
30-34	3	4	1	2
35-39	3	2	2	3
40-44	1	3	5	1
45-49	3	1	3	3
TOTALS	10	10	11	9

In terms of leisure time activities the four groups were much more similar. It might be theorized that the younger subjects participated in more vigorous activity while the older subjects had more time to participate in a greater number of activities as a result of less home care responsibility in terms of fewer young children living at home.

The relationship of homemaking and occupational activity to heart rate during recovery for all subjects is shown in Figure 5. The subjects were grouped according to activity level, completely disregarding age. There appears to be no indication from this data that any one group had a faster recovery than the other groups.

When the leisure time activity is related to heart rate during recovery (Figure 6), we find that the individuals rated as very active in leisure time activity have a more rapid recovery than any other group. The subjects having the slowest recovery rate were those in the moderately active group.

Neither 5 or 6 gives a clear indication of a relationship between level of physical activity in daily life and heart rate during recovery from submaximal work. This could be due to a lack of such a relationship or a weakness in the questionnaire used to assess the level of activity. It is



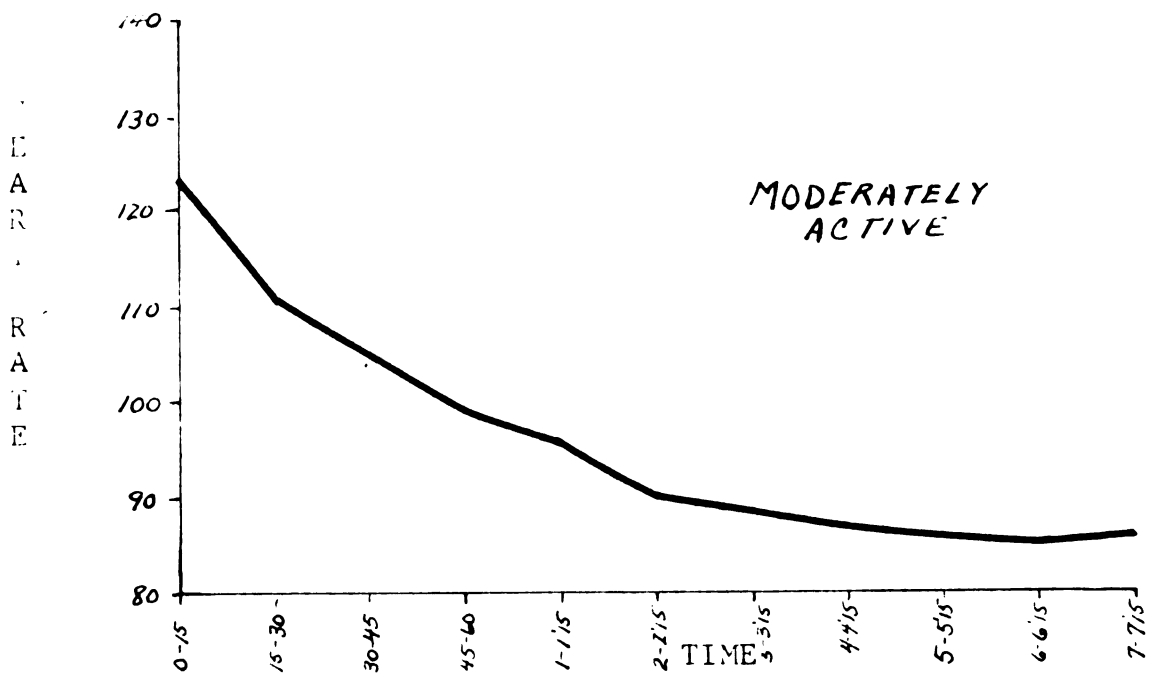
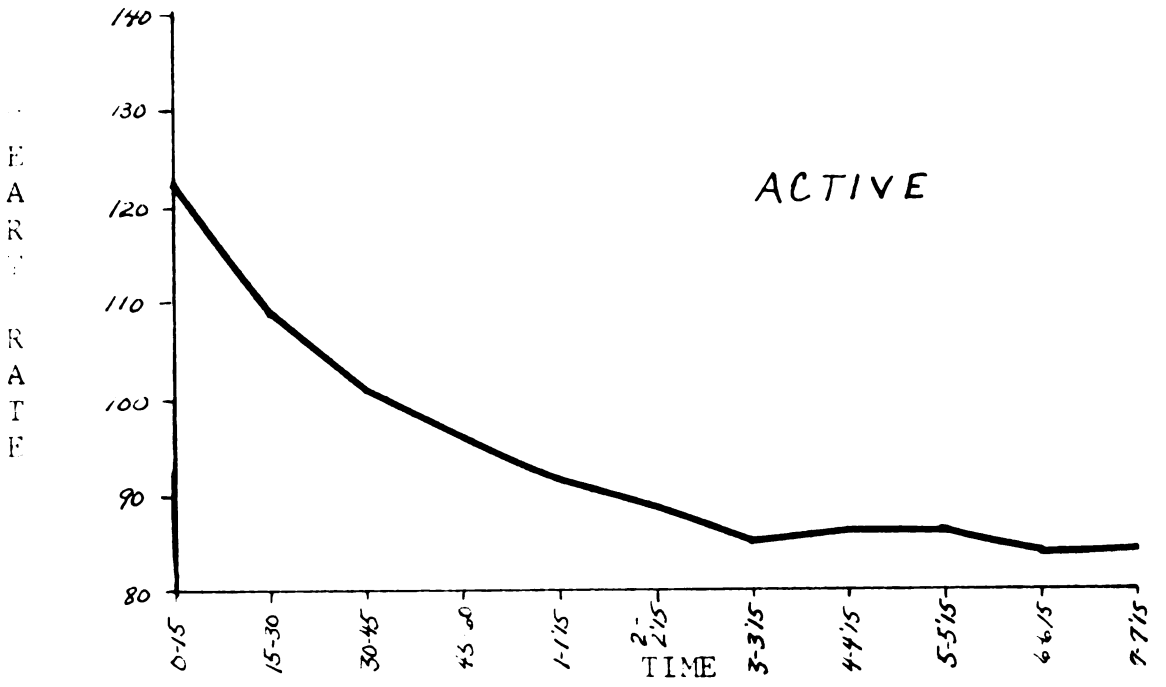


FIGURE 5

RELATIONSHIP OF HOMEMAKING AND OCCUPATIONAL ACTIVITY TO HEART RATE DURING RECOVERY



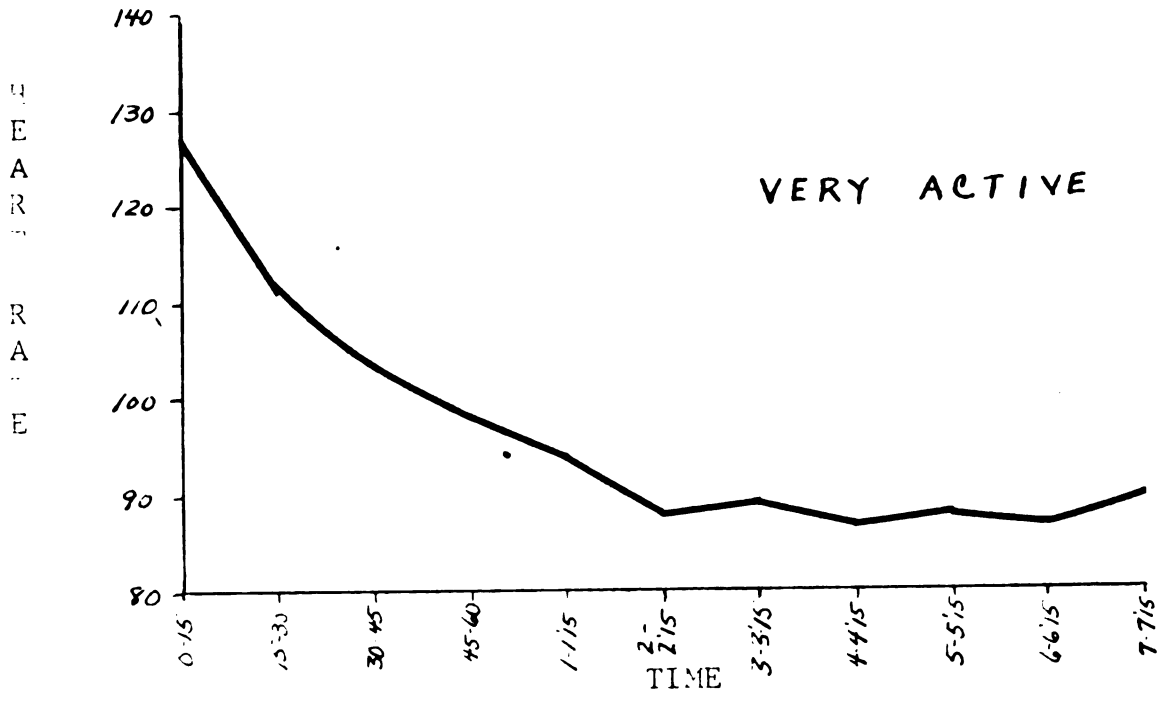
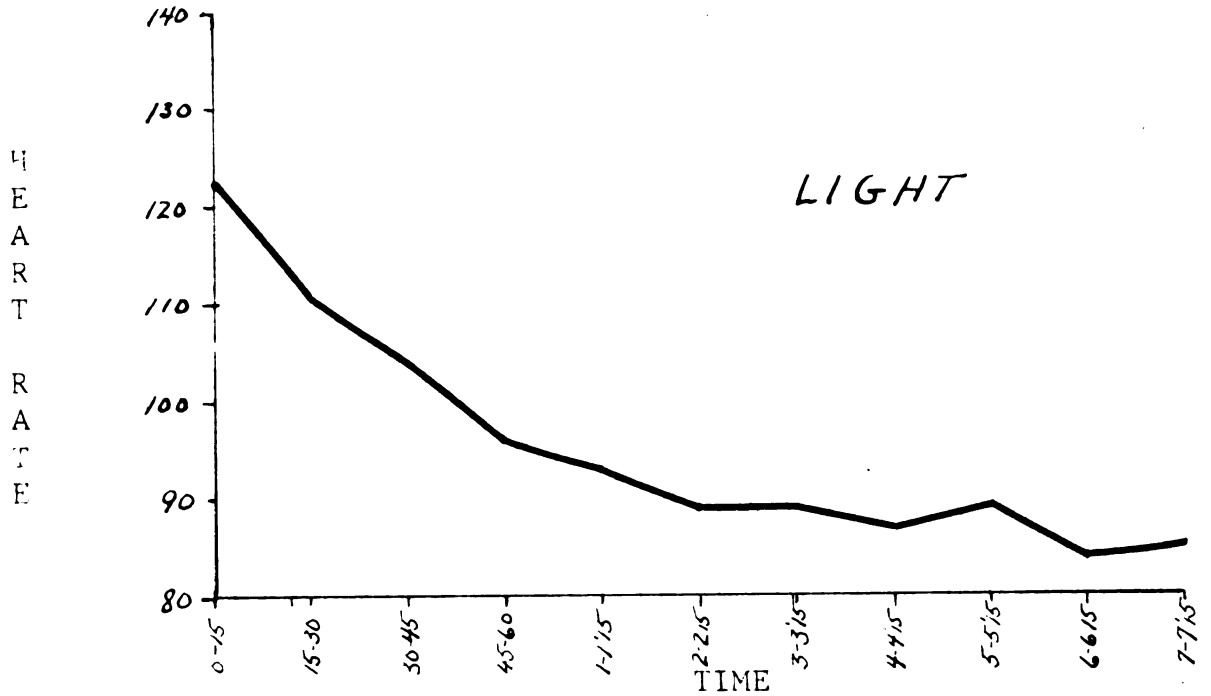


FIGURE 5

RELATIONSHIP OF HOMEMAKING AND OCCUPATIONAL

ACTIVITY TO HEART RATE DURING RECOVERY



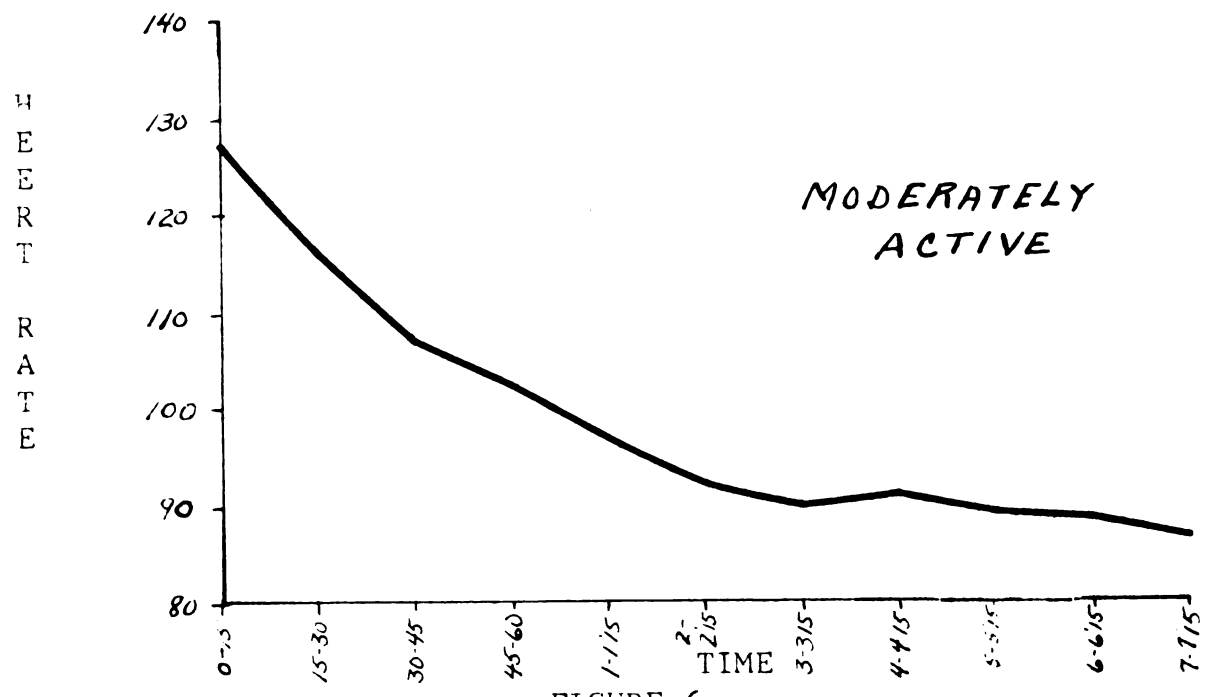
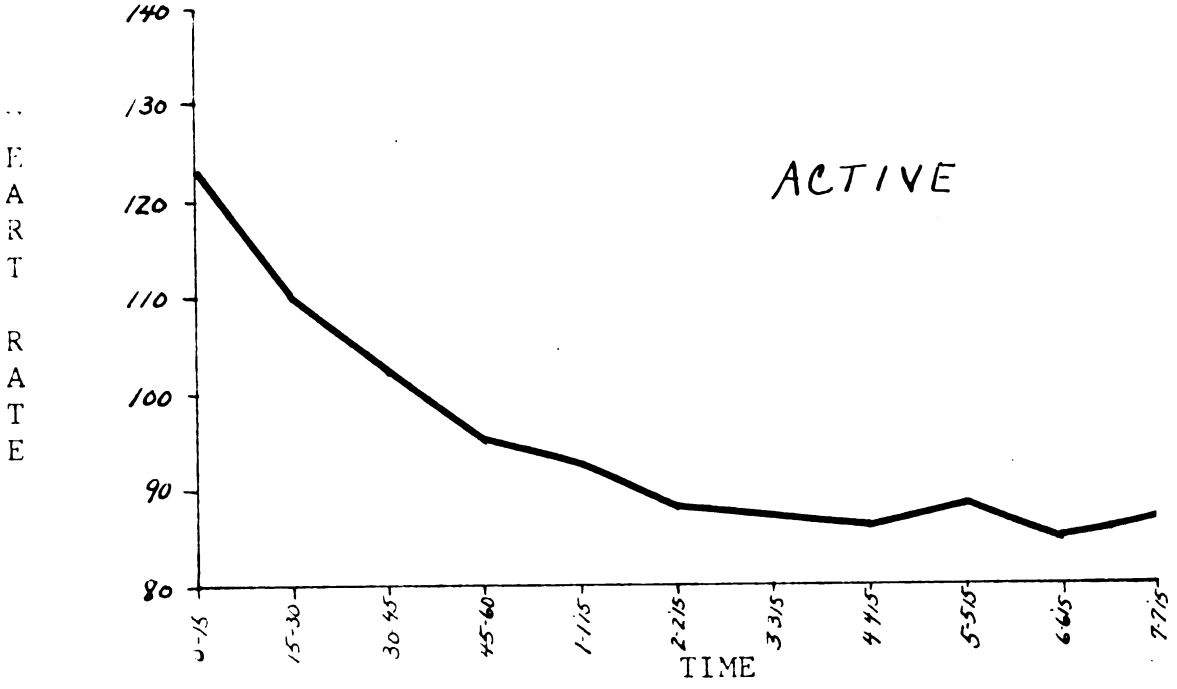


FIGURE 6

RELATIONSHIP OF LEISURE TIME ACTIVITY

TO HEART RATE DURING RECOVERY



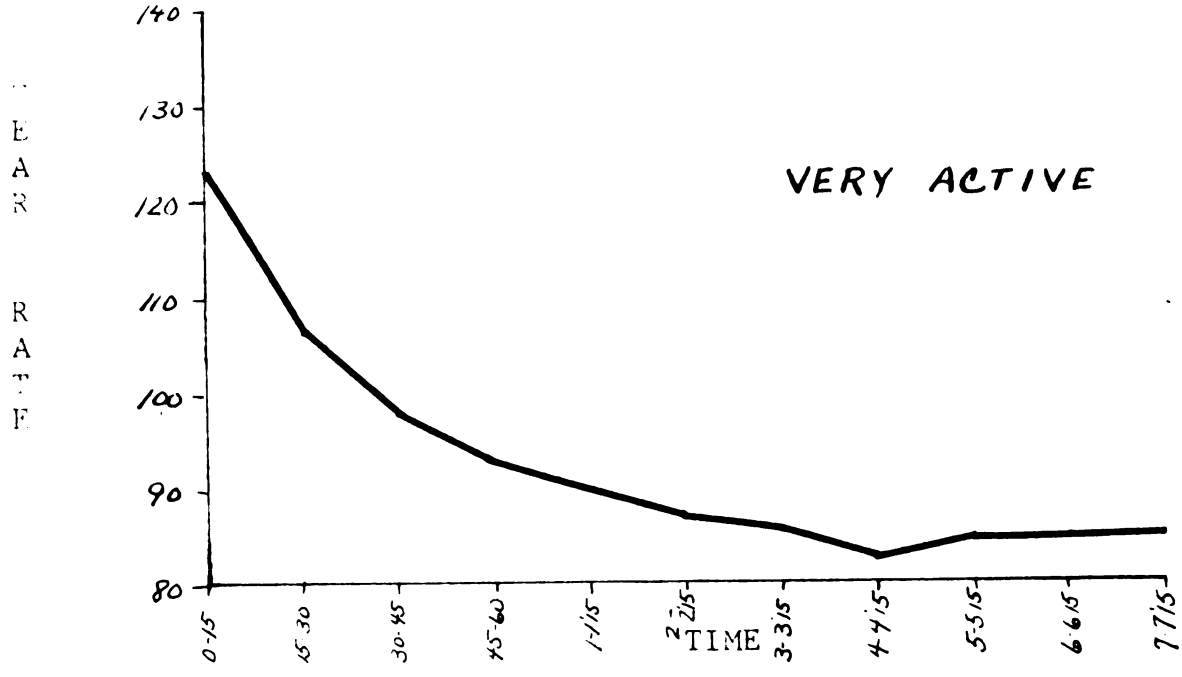


FIGURE 6

RELATIONSHIP OF LEISURE TIME ACTIVITY

TO HEART RATE DURING RECOVERY

felt that greater accuracy was attained in estimating activity level in leisure than in housekeeping activities.

Heart Rate Values And Body Composition

Figure 7 shows the recovery rates for three different groups; the forty subjects were divided into three different groups depending on their per cent of standard weight. One group contains all subjects with one standard deviation above and below the mean (twenty-nine subjects). This range includes standard weights of 82.14 to 101.83 per cent. A second group contains all subjects two standard deviations or more above the mean, and the third group contains all subjects two standard deviations or more below the mean. It can be seen from Figure 7 that those subjects two standard deviations below the mean per cent standard weight had the lowest mean heart rates and those subjects two standard deviations above the mean per cent standard weight had the highest mean heart rates. This indicates that as weight increases, work load increases and the heart rate increases proportionately.

It has been previously pointed out that individuals of different weights expend a varying amount of energy to accomplish the same task. By using the following formula, it is possible to calculate the amount of work done by an individual.

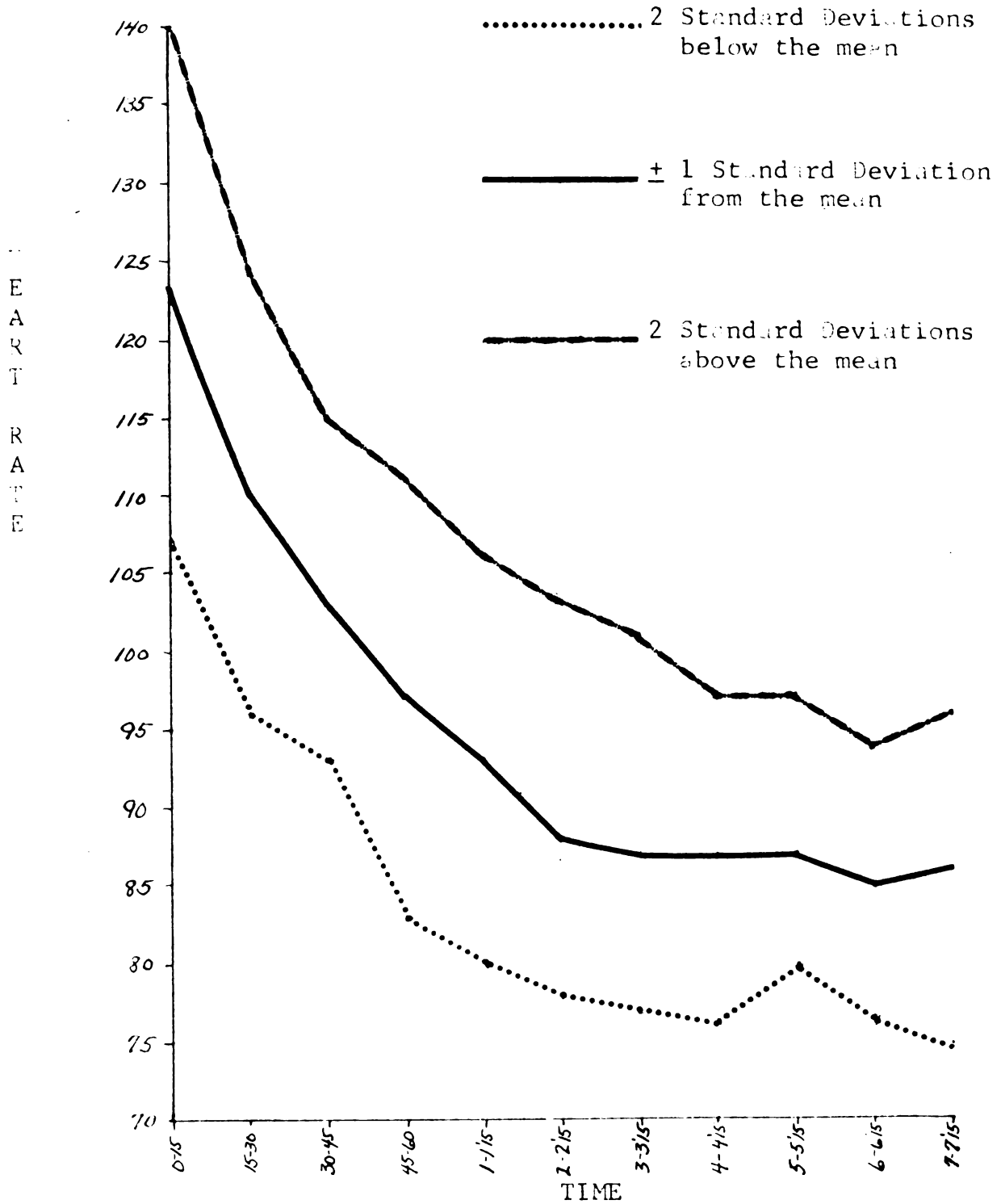


FIGURE 7

RELATIONSHIP BETWEEN PER CENT STANDARD WEIGHT AND HEART RATE DURING RECOVERY

$$\frac{\text{Body Weight X Height of Step X Number of Steps}}{12} = \text{Foot Pounds of work}$$

where height of step = 8 inches

Number of steps = 72 (24 X 3 minutes)

The following totals of mean foot pounds of work were accomplished by each age group:

30-35	6128.16 ft. lbs.
35-40	6603.36 ft. lbs.
40-45	6413.66 ft. lbs.
45-50	6152.06 ft. lbs.

It might be thought from these figures that the relatively small amount of foot pounds of work accomplished by the 45-50 year olds might be responsible for their lower mean heart rates during exercise. However, the 30-35 year olds had the highest mean heart rates during exercise and they did the least amount of work as measured in foot pounds. A correlation coefficient of .214 was obtained when correlating kilograms of body weight and maximum heart rate during exercise. This variable has a relationship to the heart rate during exercise, but it is apparent that it is not the complete answer. The correlation obtained means that 21.4 per cent of the variation in maximum heart rate between individuals during

exercise was related to variation in weight between individuals.

Figure 8 shows the recovery rates for three different groups divided by kilograms of fat free body weight. One group contains all subjects within one standard deviation of the mean fat free body weight (twenty-four subjects). This range included kilograms of fat free body weight from 38.60 to 46.30. A second group contains all subjects two standard deviations or more above the mean and the third group contains all subjects two standard deviations or more below the mean.

By dividing the subjects into these groups it can be seen that those subjects having the least kilograms of fat free body weight (two standard deviations below the mean) had the greatest recovery of any of the three groups. This is another indication that total body weight is somewhat related to heart rate recovery from submaximal work. The subjects within one standard deviation of the mean and the subjects two standard deviations above the mean kilograms of fat free body weight had very similar recovery rates.

Figure 9, showing the relationship of total body weight to fat free body weight, further substantiates the connection between total body weight and heart rate recovery from submaximal work. As noted from Figure 8, fat free body weight

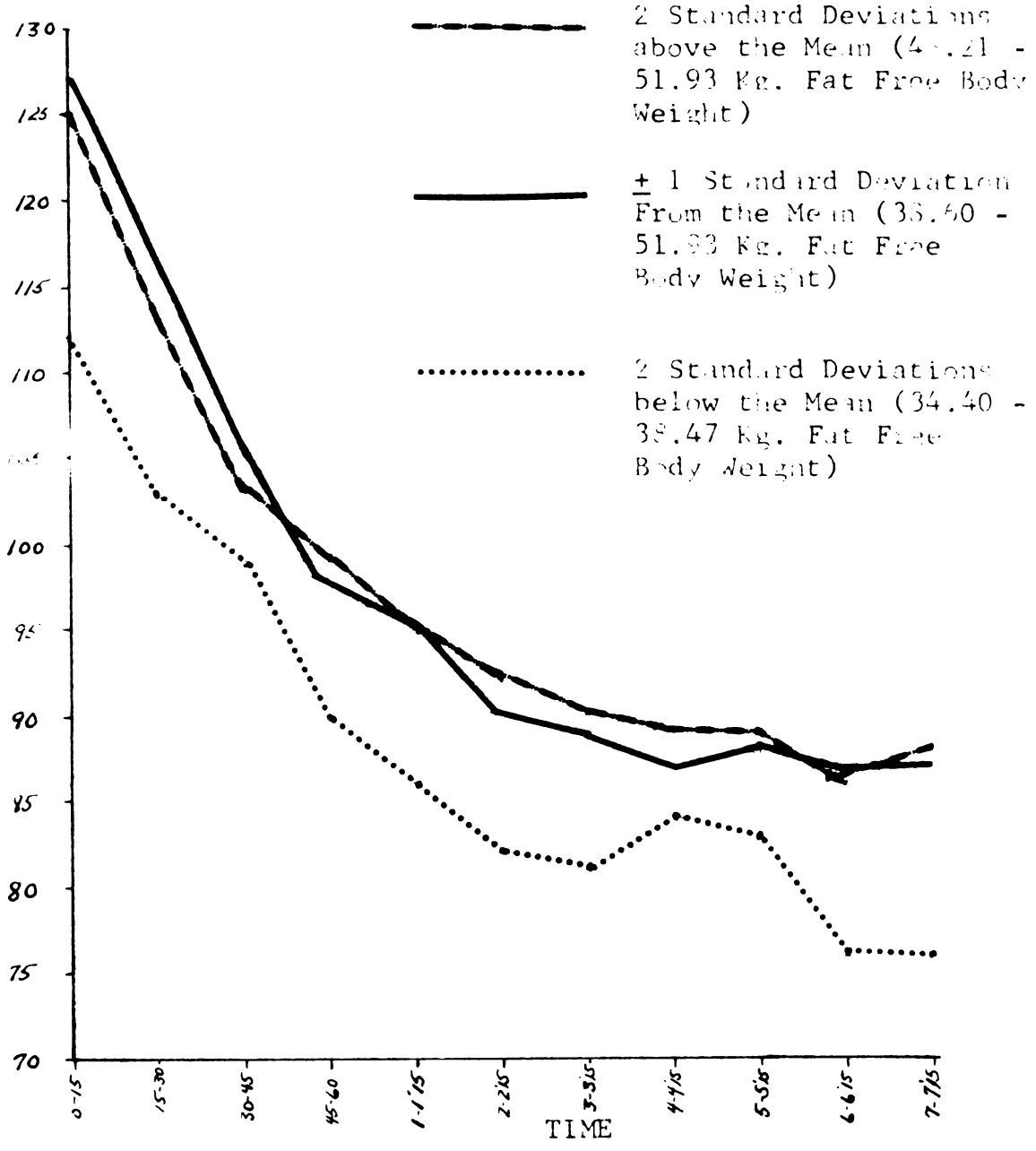


FIGURE 8

RELATIONSHIP BETWEEN FAT FREE BODY WEIGHT AND HEART RATE DURING RECOVERY

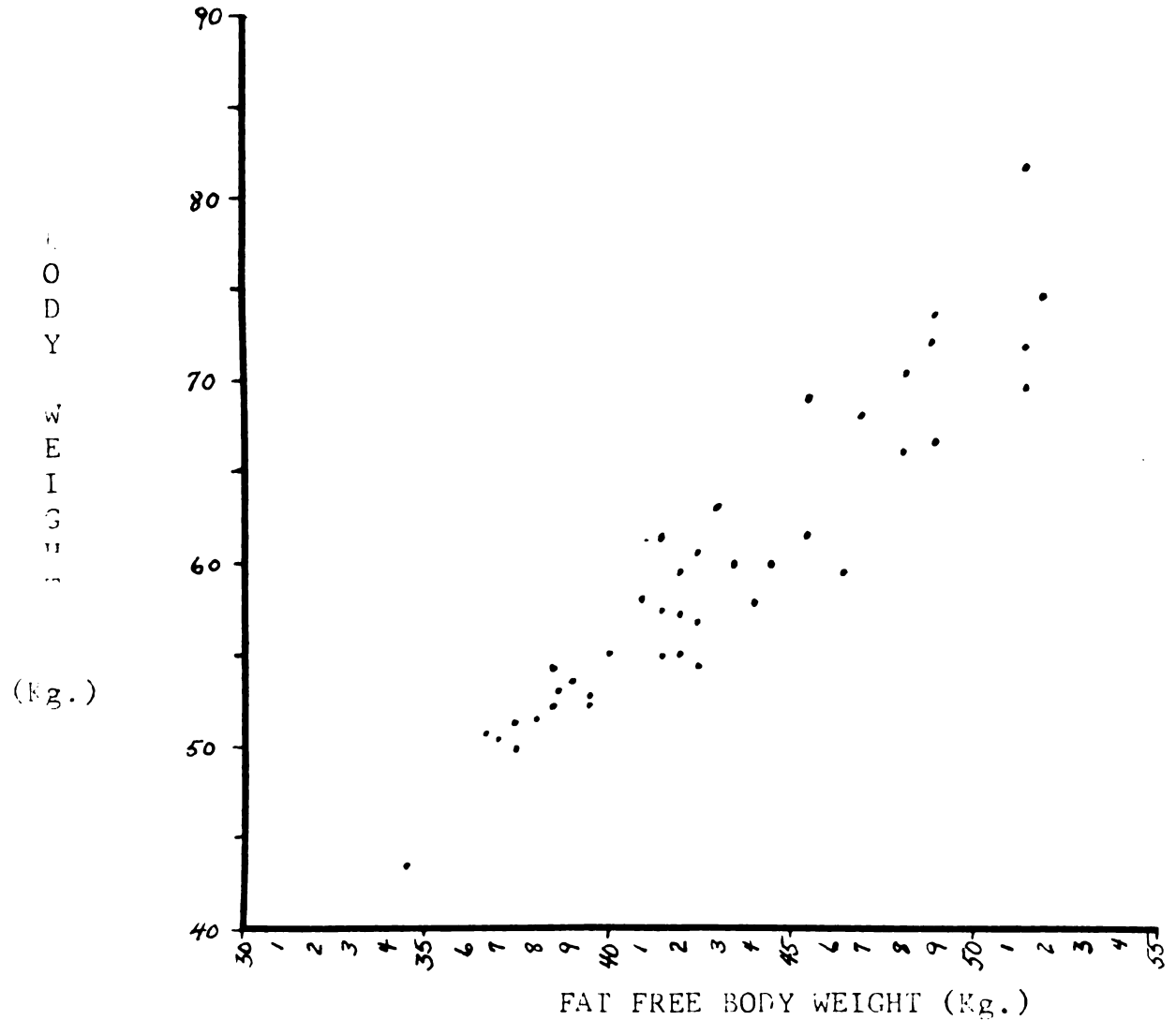


FIGURE 9

RELATIONSHIP BETWEEN BODY WEIGHT

AND FAT FREE BODY WEIGHT

was closely related to rate of recovery. Figure 9 further shows that there is a very definite relationship between fat free body weight and total body weight. This seems to indicate that there is a relationship between the total body weight of the subjects in this study and their rate of recovery from submaximal work as expressed in heart beats per minute.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

SUMMARY

As the population of the world continues to enjoy increased life expectancy, we will be continually confronted with the problems of ageing. There is a scarcity of information concerning the effects of ageing on the various body functions of both men and women, but the lack is most apparent in women.

The primary purpose of this study was to investigate age associated changes in heart rate values during and after a submaximal work test for evaluating physical fitness of women 30 to 50 years old. Closely related purposes were to study the effect of the level of physical activity in daily life and body composition on the heart rate during and after a submaximal work test.

The subject group was composed of 40 women volunteers between the ages of 30 and 50 with ten women in each five year age group. Prior to the test each subject was examined by a physician and given approval to participate in the test.

A submaximal work test was used. Each subject stepped up and down on an eight inch platform for three minutes duration at a rate of twenty-four repetitions per minute.

Heart rate recordings were taken on a Sanborn Twin-Viso Recorder prior to the step test, six times during the step test, and eleven times during an eight minute recovery period immediately following the test.

The level of physical activity was ascertained by use of an interview questionnaire in which each subject gave information on her homemaking, leisure time, and occupational activities. This information was used to assign the individuals a combined homemaking occupational rating and a leisure time rating. All subjects were rated on a four level scale of light, moderately active, active or very active.

Anthropometric measures taken were height, weight, and pubic skinfold measures. From these measures per cent of standard weight, predicted specific gravity and fat free body weight were determined for each subject.

The data obtained was analyzed by use of charts, graphs, and correlation analyses. Coefficients of correlation were obtained for the relationship between (1) age and maximum heart rate during exercise, and (2) weight and maximum heart rate during exercise.

CONCLUSIONS

The following conclusions were drawn from an analysis of the data:

(1) The subjects were primarily from the middle socio-economic class. Eighty-two and one-half per cent of the subjects were in the lower middle and upper middle classes.

(2) There is no clear indication of a relationship between level of physical activity in daily life and heart rate as assessed by the activity recall used in this study. However, it seems that those subjects most active in leisure activities recovered faster from submaximal work.

(3) Body weight, per cent of standard weight, per cent of fat of body weight, and fat free body weight were greatest in the 35-40 year age group. It appears that these measures increased for the subjects in this study to the age of 40 and then begin to decrease.

(4) There was a high positive correlation between total body weight and fat free body weight. In addition, those subjects having the least amount of fat free body weight had the greatest heart rate recovery. These two factors indicate a relationship between total body weight and heart rate recovery.

(5) Eighty per cent of the subjects in this study had per cents of standard weight less than 100 per cent. It seems that subjects volunteering for a physical fitness test tend to be underweight as compared to standard weight for age, sex and height.

(6) There seems to be no distinct age trends in maximum heart rate values during submaximal work for the subjects in this study. The older age group (45-50) were more sluggish in their response to the exercise stress and had a lower mean maximum heart rate than the other age groups. The younger women (30-35) had the highest mean maximum heart rate and the fastest response to the exercise. It is possible that the younger subjects were more subject to the effects of anticipation than were the older subjects.

(7) There seems to be no apparent age trend in heart rate values during the eight minute recovery period. However, the 30-35 year old subjects had a more rapid recovery at one minute after exercise and eight minutes after exercise than the other three groups.

(8) There seems to be a greater variation between individuals in maximum heart rate during this submaximal work test than between age groups. This would seem to be due to the many complex variables which may blur the effect of biological ageing. The subject group for similar tests should be selected from physically active individuals in order to study the effect of biological ageing on work capacity and to minimize the physical activity variable.

(9) A correlation coefficient of .214 obtained between maximum heart rate and weight shows a small relationship between these two variables. This is due in part to an increase in energy expended during the step test for the subjects of greater weight. Heart rate increased as the work load increased.

RECOMMENDATIONS

(1) The subject group for similar tests should be selected randomly and in greater numbers in order to study the effect of biological ageing on the work capacity of individuals.

(2) Each subject should have a complete trial test run on the treadmill with all apparatus that would be used in the exact test situation rather than simply a trial of the exercise performance.

(3) The test should be given in an air conditioned room, if possible, in order to eliminate any possible effects of varied external temperatures.

(4) The submaximal work test might be extended to five minutes. At the end of the three minute test used in this study the heart rate of the subjects was still increasing and had not reached a steady state.

(5) The recording of the heart rate during exercise and recovery should be made during the last fifteen seconds of each minute instead of the first fifteen seconds of each minute. This would give a better indication of the relationship between exercise and recovery heart rates. In this study the recording of the third minute of exercise was taken from two minutes to two minutes and fifteen seconds after the step test began; the actual maximum heart rate reached was not recorded. Consequently, the recovery heart rates had to be analyzed without actually knowing the maximum heart rates reached. As a result, the heart rate during the first fifteen seconds of recovery was, in some cases, higher than the recording of the third minute of exercise.

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A P P E N D I C E S

APPENDIX A

RAW DATA: AGE, HEIGHT, WEIGHT, PUBIC SKINFOLD FAT FOLD

Subject	Age (Yrs.-Mos.)	Height (Cm.)	Weight (Kg.)	Pubic Skinfold (Mm.)
30-35 Yrs.				
1	31-4	180.5	51.68	30.50
2	33-10	175.5	67.13	55.00
3	30-5	157.0	51.68	31.50
4	31-1	166.5	66.26	21.00
5	34-11	170.5	58.13	40.00
6	32-3	167.5	56.92	22.00
7	32-1	165.5	59.84	34.50
8	30-10	167.0	57.44	35.00
9	31-6	157.5	55.12	17.50
10	33-2	172.0	60.20	27.50
35-40 Yrs.				
11	37-0	172.0	73.00	46.00
12	38-4	165.0	57.24	26.00
13	39-10	156.0	52.30	26.00
14	35-7	176.5	59.44	12.50
15	38-11	166.5	59.80	41.00
16	39-4	157.0	54.60	40.00
17	36-6	169.5	60.16	33.00
18	36-3	165.5	74.84	23.50
19	37-7	169.0	52.50	25.00
20	36-7	170.0	80.54	47.00
40-45 Yrs.				
21	44-7	159.0	52.40	22.50
22	40-0	179.0	69.40	24.50
23	44-1	156.5	55.12	17.00
24	43-5	167.5	54.30	12.00
25	44-3	170.5	72.30	44.50
26	44-10	156.5	53.20	34.50
27	44-1	161.5	50.20	34.50
28	42-7	172.0	70.00	46.00
29	40-8	156.0	61.74	48.50
30	43-6	164.0	68.00	39.50
45-50 Yrs.				
31	45-8	165.5	58.12	21.00
32	46-7	160.5	63.06	42.00
33	45-1	175.0	71.86	31.00
34	48-7	157.5	50.64	36.50
35	48-0	150.0	60.00	30.00
36	48-6	172.0	61.70	31.50
37	45-9	151.5	43.94	17.50
38	49-8	159.5	50.40	37.00
39	45-4	162.0	55.00	36.00
40	46-4	173.0	66.76	25.50

RAW DATA: PREDICTED WEIGHT, PER CENT STANDARD WEIGHT, PER CENT OF FAT OF BODY WEIGHT

A

Subject	Predicted Weight (Pounds)	Per Cent Standard Weight	Per Cent of Fat of Body Weight
30-35 Yrs.			
1	135	86.66	26.24
2	159	97.48	33.91
3	132	88.64	26.79
4	146	102.05	27.09
5	150	87.33	29.44
6	146	87.67	24.76
7	142	85.21	26.98
8	146	88.61	27.79
9	132	93.94	24.85
10	150	90.00	26.04
35-40 Yrs.			
11	154	107.79	33.68
12	142	90.85	26.16
13	129	91.47	26.20
14	159	84.23	21.79
15	146	92.47	29.64
16	132	93.18	29.54
17	150	90.00	27.65
18	142	118.31	30.61
19	150	79.33	24.11
20	150	120.00	36.29
40-45 Yrs.			
21	143	82.52	23.95
22	174	89.66	25.81
23	140	88.57	23.88
24	155	78.71	21.13
25	159	101.89	32.23
26	140	85.71	27.08
27	147	76.87	25.51
28	164	96.34	31.71
29	136	104.41	33.01
30	151	100.66	31.06
45-50 Yrs.			
31	151	86.75	24.73
32	143	99.30	31.56
33	169	95.27	28.31
34	140	82.14	27.52
35	130	105.38	29.56
36	164	84.76	26.36
37	133	73.63	21.73
38	143	70.72	26.40
39	147	84.35	27.12
40	164	91.46	26.32

RAW DATA: PREDICTED SPECIFIC GRAVITY; KILOGRAMS OF FAT, AND KILOGRAMS OF FAT FREE BODY WEIGHT.

Subject	Predicted Specific Gravity	Fat (Kg.)	Fat Free Body Weight (Kg.)
30-35 Yrs.			
1	1.045	13.56	33.12
2	1.031	23.46	45.72
3	1.044	13.85	37.83
4	1.044	17.95	48.31
5	1.033	17.13	41.05
6	1.043	14.09	42.83
7	1.044	14.47	39.17
8	1.042	15.96	41.48
9	1.043	13.70	41.42
10	1.046	15.68	44.52
35-40 Yrs.			
11	1.031	24.89	49.01
12	1.046	14.97	42.27
13	1.046	13.70	38.60
14	1.054	12.95	46.40
15	1.039	17.72	42.02
16	1.039	16.13	38.47
17	1.043	16.63	43.53
18	1.037	22.91	51.93
19	1.050	12.65	39.84
20	1.026	29.23	51.31
40-45 Yrs.			
21	1.050	12.55	39.85
22	1.046	17.91	51.49
23	1.050	13.16	41.06
24	1.056	11.47	42.83
25	1.034	23.34	48.96
26	1.044	14.41	38.79
27	1.047	12.81	37.39
28	1.035	22.39	48.21
29	1.032	20.38	41.36
30	1.036	21.12	46.88
45-50 Yrs.			
31	1.049	14.20	43.92
32	1.035	19.90	43.16
33	1.041	20.34	51.52
34	1.044	14.02	36.92
35	1.039	17.97	42.83
36	1.045	16.26	45.44
37	1.054	9.54	34.40
38	1.045	13.35	37.05
39	1.044	14.92	40.08
40	1.043	17.57	49.19

Subject	Resting	EXERCISE 0-15 sec.	15-30 sec.	30-45 sec.	45-60 sec.	1'-1'15"	2'-2'15"
30-35 years							
1	99	113	114	120	120	127	133
2	85	103	112	124	123	130	140
3	93	124	131	134	133	137	133
4	79	107	121	126	136	145	151
5	60	96	105	108	116	120	127
6	83	109	115	120	124	130	140
7	71	96	103	108	112	119	131
8	114	116	142	153	155	161	167
9	81	118	116	116	122	128	134
10	64	82	91	103	106	113	119
35-40 years							
11	94	118	120	125	129	130	137
12	79	93	101	113	119	123	122
13	82	108	103	108	116	121	120
14	79	89	99	104	108	112	119
15	87	116	123	131	137	145	153
16	79	107	111	114	119	124	135
17	71	99	100	106	110	116	126
18	83	103	106	109	115	113	120
19	77	94	101	102	108	111	120
20	92	126	130	136	142	149	157

HEART RATE VALUES AT REST AND DURING EXERCISE (Cont'd.)

Subject	Resting	EXERCISE 0-15 sec.	15-30 sec.	30-45 sec.	45-60 sec.	1'-1'15"	2'-2'15"
40-45 years							
21	79	96	106	110	114	117	118
22	65	74	83	94	98	99	104
23	90	120	129	134	139	145	156
24	84	116	121	127	127	128	130
25	85	106	108	112	118	118	122
26	88	110	112	117	120	123	131
27	74	90	93	102	108	111	115
28	71	84	97	100	105	110	116
29	96	134	140	148	154	161	178
30	83	116	125	132	131	134	146
45-50 years							
31	87	112	116	118	124	128	141
32	80	100	102	108	112	115	120
33	100	117	127	132	136	140	148
34	84	96	102	112	116	118	123
35	60	104	109	113	118	123	140
36	70	93	103	113	121	130	139
37	61	85	92	93	100	104	113
38	88	94	92	100	104	110	112
39	88	102	106	111	115	120	131
40	73	96	105	112	118	124	135

RAW DATA: HEART RATE VALUES DURING RECOVERY

Subject	sec. 0-15	sec. 15-30	sec. 30-45	sec. 45-60	1'- 1'15"	2'- 2'15"	3'- 3'15"	4'- 4'15"	5'- 5'15"	6'- 6'15"*	7'- 7'15"*
30-35 yrs.											
1	118	115	112	104	100	100	95	99	99	-	-
2	146	130	117	110	104	99	88	88	93	-	-
3	126	112	100	85	80	83	77	91	84	-	-
4	132	116	108	106	99	98	98	94	95	87	95
5	102	91	79	72	74	80	69	65	73	77	64
6	127	117	106	99	96	100	90	99	93	94	92
7	131	113	103	97	97	89	94	87	83	82	84
8	152	128	123	124	116	107	102	105	105	98	97
9	123	102	105	88	94	92	92	92	104	91	98
10	98	89	84	83	71	67	68	72	69	68	68
35-40 yrs.											
11	138	132	125	123	113	106	104	101	97	100	101
12	118	94	83	82	75	70	81	79	73	77	87
13	126	114	107	100	98	96	93	97	93	92	99
14	116	98	89	77	73	67	67	70	79	76	72
15	136	124	118	113	110	104	103	105	97	97	94
16	120	113	110	104	101	85	86	84	96	83	85
17	118	104	99	94	92	81	74	72	71	73	76
18	120	102	93	88	92	84	85	84	86	81	85
19	114	104	98	97	87	94	89	88	89	84	85
20	154	138	129	121	120	122	120	116	108	102	100

* 5 subjects had only a six minute recovery period.

HEART RATE VALUES DURING RECOVERY (Cont'd.)

Subject	sec. 0-15	sec. 15-30	sec. 30-45	sec. 45-60	1'- 1'15"	2'- 2'15"	3'- 3'15"	4'- 4'15"	5'- 5'15"	6'- * 6'15"	7'- * 7'15"
40-45 yrs.											
21	114	103	96	89	87	86	82	83	81	-	-
22	83	94	74	74	67	59	61	59	62	63	69
23	145	123	123	113	115	99	111	98	104	95	105
24	119	103	99	89	86	84	84	83	86	85	85
25	119	104	96	94	90	88	87	88	88	90	87
26	122	113	107	105	98	88	88	85	84	88	97
27	103	93	89	82	79	74	75	74	68	73	74
28	105	94	87	82	79	79	79	79	79	76	80
29	165	146	140	138	128	130	120	128	112	113	105
30	127	120	114	107	102	102	100	100	101	100	101
45-50 yrs.											
31	137	129	123	118	117	104	102	98	96	-	-
32	114	102	90	84	81	78	78	74	74	81	78
33	138	131	122	114	112	111	105	104	100	101	104
34	120	111	105	101	93	92	96	100	89	89	88
35	132	111	95	89	80	79	80	79	84	85	87
36	133	126	109	102	98	98	86	91	89	89	77
37	100	85	83	78	73	68	64	67	67	67	64
38	100	92	84	81	74	72	72	74	68	78	68
39	120	113	105	103	99	89	95	92	87	92	91
40	126	102	92	90	84	82	81	83	84	81	83

* 5 subjects had only a six minute recovery period.

APPENDIX B.

FORMULAS USED FOR PER CENT OF FAT OF BODY WEIGHT, KILOGRAMS OF FAT OF BODY WEIGHT, KILOGRAMS FAT FREE BODY WEIGHT

(1) Per cent fat of body weight*

$$\text{Per cent fat} = 100 \left(\frac{5.548}{\text{Specific gravity}} - 5.044 \right)$$

(2) Kilograms of fat of body weight

Kilograms fat = per cent fat × body weight in kilograms

(3) Kilograms of fat free body weight

Kilograms fat free body weight = body weight in Kg.
- Kgs. fat

*Rathbun and Pace, "Body Composition I", Journal of Chemistry 1953:674, 1945.

PREDICTION FORMULA FOR SPECIFIC GRAVITY

(1) Specific gravity = $1.0934 - .0004231_{x_1} - .0003401_{x_{13}}$

when X_1 = Skinfold.

APPENDIX C.

ACTIVITY RECALL QUESTIONNAIRE

NAME

MARITAL STATUS

OCCUPATION

What is the highest grade completed? (Husband's, if married)

1. _____None 2. _____ Elem. 1-3
3. _____Sec. 4._____ College 1-5

What is the highest degree awarded to you? (Husband's, if married)

1._____ High school diploma
2._____ Bachelor's
3._____ Master's
4._____ Doctorate
5._____ Other (specify)

What is the major source of your family income?

1._____ Inherited Savings and Investments
2._____ Earned Wealth
3._____ Profits, Fees, Royalties
4._____ Salary, Commissions
5._____ Wages on hourly basis
6._____ Odd jobs or Seasonal work
7._____ Public Relief

Have you participated in any of the following activities during the past twelve months?

Activity	Participation		
	1 x week	2-3 x week	4 or more x week
Croquet			
Fishing			
Power Boating			
Shuffleboard			
Skeet Shoot			
Archery (target-field)			
Bowling			
Camping			
Lawn Bowling			
Sailing			
Table Tennis			
Ice Boating			
Canoeing			
Golf			
Horseback Riding			
Social Dancing			
Walking (recreational)			
Archery (hunting)			
Home Conditioning Exercises			
Bicycling (recreational)			
Folk-Square Dancing			
Hunting			
Ice Skating			
Roller Skating			

Activity	Participation		
	1 x week	2-3 x week	4 or more x week
Rowing Boat			
Swimming			
Hiking Cross Country			
Scuba Diving			
Softball			
Volleyball			
Weight Lifting			
Gymnastics			
Mountain Climbing			
Water Skiing			
Wrestling			
Handball			
Ice Hockey			
Badminton			
Basketball			
Fencing			
Snow Skiing			
Soccer			
Squash			
Tennis			
Gardening			

Activity

What is the size of your garden?

_____ No garden

_____ 30x20 to 30x100

_____ 60x100

_____ 100x100

How often do you work in the garden?

_____ Once per week

_____ 2-3 x week

_____ 4 or more x week

What is the size of your yard?

_____ No yard

_____ Less than 1/4 acre

_____ 1/4 to 1/2 acre

_____ 1/2 to 1 acre

_____ More than 1 acre

How often do you take care of your lawn?

_____ Never or less than 1 x week

_____ 1 x week

_____ 2-3 x week

What equipment do you use in working on your lawn?

_____ Riding mower

_____ Power mower

_____ Hand mower

Have you done any of the following maintenance activities in the past twelve months?

_____ Minor repairs only

_____ Putting, taking off Screens and Storm windows

_____ Painting walls

_____ Tiling floors or walls

_____ Building garage

_____ Cementing patio

_____ Cleaning furnace

_____ Painting house

_____ Building Furniture

_____ Building extra room

_____ Cementing driveway

_____ Other

_____ None

Enter an X for the description of dwelling unit.

Dwelling Unit	Number of Rooms
_____ House	_____
_____ Apartment	_____
_____ Farm	_____
_____ Other	_____

Enter an X for the number of times you engage in the following activities.

	All the time	2-3 x week	1 x week
Daily pick up	_____	_____	_____
Weekly cleaning	_____	_____	_____
Washing	_____	_____	_____
Ironing	_____	_____	_____
Food preparation	_____	_____	_____
Clean up after meals	_____	_____	_____

How many children and/or adults of the following ages do you have living with you?

Number	Age	Number	Age
____	Baby -5	____	30-40
____	5-10	____	40-50
____	10-20	____	50-60
____	20-30	____	60 or over

How many children or adults do you care for with a chronic Condition or physical impairment?

____ None Age ____

____ Children Age ____

____ Adults Age ____

Enter an X for those activities which you have participated in during the past twelve months.

	2-3 x month or less	1 x week	2-3 x week	4 or more x week
Church				
Civic-service club				
Grange				
Fraternal organization				
PTA or PTC				
Business-professional organization				
Other				

RATING SCALE FOR ACTIVITY LEVEL

I. HOMEMAKING/OCCUPATIONAL INDEX

A. Homemaking Index

1. Size of home

2. Family size and composition

3. Homemaking activities

4. Home improvement and maintenance

5. Lawn Care

B. Occupational Index

II. LEISURE INDEX

1. Sports and garden

2. Community activities

A. Homemaking Index

1. Size of home - point value is equal to number of rooms in the home

2. Family size and composition

Ages	Number of Individuals		
	1	2	3
Adults	1	2	3
Children			
10-20	2	4	6
5-10	3	6	9
0-5	4	8	12
Chronic Invalid Adult	2	4	6
Chronic Invalid Child	4	8	12

3. Homemaking Activities

	All the time	2-3 x week	1 x week
Food Preparation	3	2	1
Clean up after meals	3	2	1
Pick up	6	4	2
Weekly cleaning	9	6	3
Washing	12	8	4
Ironing	12	8	4

4. Home improvement and maintenance

Building; room, garage Cement work; drive or patio	12
Painting; house, walls Tiling floors; Building furniture	9
Cleaning; furnace, Storm windows; Washing walls	6
Minor repairs	3

5. Lawn care

a. Size

	1 x week	2-3 x week
More than 1 acre	4	8
1/2 to 1 acre	3	6
1/4 to 1/2 acre	2	4
Less than above	1	2

b. Equipment used

	1 x week	2-3 x week
Hand mower	4	8
Power mower	3	6
Riding mower	2	4

B. Occupational Index

No point ratings were given for occupation. The ratings of light, moderately active, active, or very active were taken from "Estimates of worker trait requirements for 4,000 jobs as defined in the Dictionary of Occupational Titles" of the U. S. Department of Labor, Bureau of Employment Security.

II. Leisure Index

1. Sports

Activity	Class	Activity	Class

Sports Rating Scale

Category	2-3 x month 1 x week	2-3 x week	4 or more x week
Light	1	2	3
Moderately Active	2	4	6
Active	3	6	9
Very Active	4	8	12

Garden Rating Scale

Size of garden	1 x week	2-3 x week	4 or more x week
30x 20 to 30x100	1	2	3
60x100	2	4	6
100x100	3	6	9

2. Community Activities

Activity	2-3 x month	1 x week	2-3x week	4 or more x week
Church	1	2	3	4
Civic-Service	1	2	3	4
Grange	1	2	3	4
Fraternal Organization	1	2	3	4
Extension	1	2	3	4
PTA - PTC	1	2	3	4
Business-Professional	1	2	3	4
Other	1	2	3	4

LEVEL OF ACTIVITY RATINGS

SUBJECT	HOSPITAL IN-PATIENT ACTIVITY	LEISURE
30-35 Years		
1	A	L
2	A	[illegible]
3	L	[illegible]
4	A	L
5	A	VA
6	VA	A
7	[illegible]	L
8	[illegible]	NA
9	[illegible]	VA
10	A	[illegible]
35-40 Years		
11	[illegible]	NA
12	[illegible]	VA
13	[illegible]	A
14	L	L
15	A	[illegible]
16	[illegible]	L
17	[illegible]	VA
18	VA	VA
19	L	L
20	[illegible]	A

LEVEL OF ACTIVITY RATINGS

C

SUBJECT	HOMEMAKING/OCCUPATIONAL	LEISURE
40-45 Years		
21	VA	MA
22	MA	MA
23	VA	A
24	MA	A
25	MA	A
26	VA	A
27	L	L
28	A	A
29	MA	VA
30	A	MA
45-50 Years		
31	L	MA
32	VA	VA
33	L	L
34	L	L
35	A	L
36	L	A
37	MA	A
38	MA	A
39	MA	VA
40	A	VA