The Relationship Between Adiposity and Functional Capacity in 60 Women Attending Utah State University 1975-76

Barbara P. Gibbs

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THE RELATIONSHIP BETWEEN ADIPOSY AND FUNCTIONAL CAPACITY IN 60 WOMEN ATTENDING UTAH STATE UNIVERSITY 1975-76

by

Barbara P. Gibbs

A thesis submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE in

Health, Physical Education, and Recreation

Approved:

UTAH STATE UNIVERSITY
Logan, Utah

1977
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Barbara P. Gibbs
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ABSTRACT

The Relationship Between Adiposity and Functional Capacity in 60 Women Attending Utah State University 1975-76

by

Barbara P. Gibbs, Master of Science
Utah State University, 1977

Major Professor: Dr. Lanny J. Nalder
Department: Health, Physical Education and Recreation

The purpose of this study was to test whether a relationship exists between adiposity and functional capacity. A moderate negative correlation was found between adiposity and functional capacity. This indicates that as adiposity increases, functional capacity decreases.

(76 pages)
CHAPTER I
INTRODUCTION

At the Obesity Association's symposium, held at the Royal Society of Medicine in London, October 19, 1968, obesity was discussed as a major health problem that requires urgent medical and scientific attention. At this symposium it was conservatively estimated by Professors Butterfield and I. McLean Baird that about one half of the population is above their desireable weight. Childhood obesity is becoming increasingly prevalent and eighty per cent of these obese children will become obese adults. 1,2

Obesity has been associated with excess mortality, 50% in men and 20% in women, due to cardiovascular diseases and other such degenerative diseases as diabetes, gout, gall bladder disease, hypertension, and hyperlipedemia. In addition systolic blood pressure, blood cholesterol, blood sugar, and uric acid levels have been shown to rise as weight increases. Eventually cardiac hypertrophy and congestive heart failure may supervene.

In women, however, there is no independent effect of obesity in connection with angina pectoris and sudden death, but there is a strong relationship with obesity when it is present in association with hypertension, higher cholesterol levels and diabetes.\(^3\)

In addition to being aesthetically displeasing there is difficulty in breathing, back problems, poor mobility, digestive ailments, increased heart attack risks, fatigue and poor self esteem that are related to obesity.\(^4,5,6,7,8\)

Whether the cause be organic, psychogenic or cultural, overeating is responsible for obesity. Other factors implicated in obesity are heredity, environment, emotional disturbances, self-indulgence, hormonal imbalance, sedentary living, misinformation and ignorance of proper eating habits and nutrition. Another cause could be due to damage to the appetite control center or hypothalamus in the brain.


Only a small percentage of obesity is caused by metabolic disorders. Whatever the physiological or psychological causes are, overeating and underexercising contribute to obesity.  

In a 16 year evaluation by the Framingham Heart Study of 5,000 men and women, (defining obesity as 20% above median weight) it was determined that the more educated persons were leaner than the less educated. Women tended to increase in weight with each decade after 30 years of age. The increase of the prevalence of obesity was 8% in the fourth decade to 23% in the sixth. They discovered that moderate smokers were leaner than heavy smokers who were fatter and generally tended to be given to excesses of everything.  

Physical fitness increases with cardiovascular endurance training. A sedentary individual will have a lower capacity for cardiovascular endurance than one who has been trained, due to the body's inability to perform under physical stress without adequate preparation or training. One who has been trained will be able to withstand more

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10 H. Emerson Thomas, Jr., M. D., William B. Kannel, M. D., and Patricia M. McNamara, Medical Times, 1099-1106.
physical stress for longer periods of time. The anthropometrical changes that take place involve a decrease in body fat and an increase in muscle mass with variations in total body weight. 

In a study of the physical and motor fitness of 3,400 boys and girls, grades 4 through 12, it was discovered that there was a progressive decline in the girls' fitness scores through the junior and senior high school grades. At the International Symposium on Physical Activity and Cardiovascular Health in October, 1966, it was reported that there was a marked contrast observed between the fitness indexes of urban North America and the circumpolar regions of Scandinavia. The population of North America showed a steady decline from their maximum aerobic power from their early teens onward.

The Scandinavians, on the other hand, who were more active physically maintained a high level of maximal aerobic capacity throughout adult


12 Robert A. Bruce, M.D., "Physiological and Medical Aspects of Cardiac Rehabilitation," Needs and Opportunities for Rehabilitating the Coronary Heart Disease Patient, Report of the Task Force on Cardiovascular Rehabilitation of the National Heart and Lung Institute, DHEW Publication No. (NIH) 75-750, (1975), 87-93.


life. It was determined that the medical, nutritional, psychological and sociological aspects of human fitness have need of urgent attention for more comprehensive studies. 15

The relationship between fitness and fatigue in women was found to be related to the amount of physical activity and to a history of childhood inactivity. Those who were chronic complainers of fatigue were less active physically. In addition the more physically fit group had less of all the common complaints; menstrual discomforts, backaches, digestive disorders, fatigue, colds, allergies, and headaches. They found that the taller, heavier females scored highest on physiological fitness tests. It was speculated that this was due to more muscle mass in the fit group, whereas adipose tissue may have provided the weight in the low fitness group. 16

As was discussed earlier, obesity increases the risks of various degenerative diseases, as well as functional capacity (\(V_{O_2}\) max). It is known that weight reduction in obese persons improves functional capacity and reduces the risk of initial or subsequent coronary heart disease events. 17 However, it appears that limited research has been

17 Carl C. Seltzer, Ph. D., Minnesota Medicine, 1265-1270.
conducted to determine at what level of adiposity, functional capacity becomes impaired.

Justification of the Study

It appears that there has been limited research conducted to determine the relationship between adiposity and functional capacity. Research indicates that obesity impairs exercise tolerance and that sedentary individuals have lower functional capacity than active persons. However, little has been written concerning the relationship between adiposity and functional capacity in the mean population. Therefore, this study sought to determine if this relationship exists.

Statement of the Problem

The purpose of this study was to determine if a relationship exists between adiposity and functional capacity, in 60 women, ages 18-39, attending Physical Education Activity classes at Utah State University, Logan, Utah.

More specifically, this study was designed to determine:

1. If adiposity affects functional capacity.

2. If so, what percentage of adipose tissue is present when functional capacity is below normal or "good" (11.05 METS and below).
Basic Assumptions

Prior to the treadmill test, the subjects who participated were questioned concerning their weekly cardiovascular exercise frequency in the previous month. It was assumed that they were accurate in their calculations. In addition, each subject was explained the importance of a maximum effort on the treadmill test. It was assumed that this condition was met by each individual.

Delimitations

This study was delimited to 60 women ranging in age from 18-39 attending Utah State University physical education activity classes during winter and spring quarters, 1975-76. One visit was made per person to the Human Research Center for testing. Measurements of adiposity and functional capacity were completed during this visit.

Limitations

It was recognized that the following variables could not be controlled in this study.

1. The inability to control the subjects' diet, amount of sleep, attitude adjustment, anxiety level and personal motivation at the time of testing.
2. In addition, the subject's previous additional physical activity, and any other daily living involvements could have affected testing results.

It was assumed that none of these limitations were significant enough to adversely affect the results of this study.

**Definition of Terms**

1. **Adiposity**—Percentage of external and internal body fat.
2. **Expiratory Reserve Volume**—The maximal volume that can be exhaled following a normal exhalation.
3. **Functional Capacity**—A measure of physical fitness as determined by maximal oxygen consumption (\( \dot{V}O_2\text{max} \)) or METS.
4. **Functional Residual Capacity (FRC)**—The volume of air left in the lungs after a quiet exhalation, it is composed of the expiratory reserve volume and the residual volume.
5. **One MET**—A unit of work equal to 3.5 milliliters of oxygen per kilogram of body weight per minute (3.5 ml/kg/min).
6. **Residual Volume (RV)**—The volume of air left in the lungs and airways after forced maximal expiration.
7. **Total Lung Capacity (TLC)**—The amount of gas contained in the lungs at the end of a maximal inspiration.
8. **Vital Capacity**—The maximal volume of air that can be expelled from the lungs following a maximal inspiration.
CHAPTER II
REVIEW OF RELATED LITERATURE

Research efforts associated with adiposity and functional capacity have increased significantly in the past decade. Methods for measuring adiposity are numerous and range from very simple to complex formulas. Functional capacity can be determined in a variety of ways utilizing elaborate laboratory facilities or equipment available in most public school systems. Numerous research studies have examined the relationship of obesity to functional capacity, as well as other important components of physical and mental health.

On the basis of this concern, Chapter II has been presented in the following sections: (a) Guidelines for Adiposity: Reliability of Testing Procedures and Related Research, (b) Guidelines for Functional Capacity Testing: Reliability of Testing Procedures and Related Research, (c) Related Literatures Pertaining to Adiposity and Functional Capacity.

Guidelines for Adiposity:

Reliability of Testing Procedures and Related Research

Adiposity is determined by the percentage of fat present on the body. It is measurable using several different techniques. It can be
obtained by the informal Pinch Test, by anthropometric measurements or by obtaining skin fold measurements from selected sites on the body. Other techniques of measuring adiposity are by specific gravity using hydrostatic weighing, by determination of total body water using an antipyrine or chiorganate distribution technique and by measuring the prolonged uptake of cylopropane from a closed breathing circuit.

The Pinch Test is the simplest method and is obtained by pinching any fatty area of the body. If the thickness of the skin is one inch or more the person is too fat. Due to structural differences and inaccuracy in measuring, it is never precise or reliable. ¹

Anthropometric measurements vary in reliability with the considerations taken by those developing the weight chart. In 1921, Matiegka first attempted to estimate body composition and from his attempt was developed the concept of standard weight for height. ² The standard or median weight chart is usually defined as the average weight of persons of a given sex, age, and height. These are determined by averaging groups of people within these specifications. In the United States, people tend to gain weight as they mature and are


more adipose in general. This method of determining proper weight is inaccurate and too high.  

In the 1950's William H. Sheldon developed a method of body build classification, known as somatotyping. The three primary components are called endomorphy, mesomorphy and ectomorphy. Endomorphy is characterized by body roundness and a general tendency towards excess adipose tissue. Mesomorphy is a muscular body with large bone structure. Ectomorphy is evidenced by small bones and frail muscular structure. There are various combinations of these three classifications to cover all types of body builds. For research purposes, a person must be extensively trained to accurately somatotype persons. For this reason it is impractical as a simple test for classifying body builds, or as a general assessment of adiposity.

Accuracy in estimating adiposity by skinfold measurements depends primarily on the preciseness of the skinfold determinations, since the thickness of the subcutaneous layer of fat is the same over a limited surface area. It is preferable that the same investigator obtain all the measurements in a study, due to individual variations in

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technique. It is a relatively simple and inexpensive method; however, only external fat is measurable using this method.\textsuperscript{5}

In a study on 87 Chinese men and women, T. H. Allen et al. determined that there were individual variations and characteristic sexual differences in adiposity placement. Of ten areas measured; cheek, chest, upper arm, abdomen, back, waist, calf, side, knee and chin, women were thicker at the chin, the back, flanks and lower extremities. The number and location of the sites were such that the total thickness (sum of the thickness at ten sites) were similar in both sexes, provided that the adiposities were the same. They concluded that total adiposity can be determined with skinfolds with a standard deviation of 2.02 kg.\textsuperscript{6}

Fletcher measured total body fat using skinfold calipers. All nine sites were located on the chest, back and biceps. In women, the readings from the left side were 5-10\% higher than from the right. He classified the women who were 30\% over their expected weight according to their fat distribution. Those who had large hips and buttocks with thin shoulders had thinner folds. He found that although the


women's skinfolds were twice as thick as men's, the proportions at different sites were almost identical in the sexes. However, unlike Allen, et al. the sites examined represented only 25% of the body surface area. As mentioned earlier, Allen found that there were sexual differences in the distribution of fat. Women tended to be heavier in the lower extremities. Fletcher also discovered that gains or losses in extra-cellular fluids (intracellular) did not seem to affect fat folds.

In 1971 Hermansen and Doblen regarded the body as a three-phase system consisting of skeleton, soft fat free tissue and extraskletal fat. Higher covariation with skinfold measurements was obtained due to independent anthropometric measurements. They determined that the error in estimation of total body fat by skinfold measurements was due to the personal techniques of the investigator, the age and adiposity of the subjects. They determined that women had a higher percentage of fat than men and found that the correlation between fat and abdominal skinfolds was higher than any other skinfold measurement.

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fact that all were physically active Caucasians, which could have accounted for the differences in fat distribution,\textsuperscript{10} as found by Allen, et al. whose subjects were Chinese.\textsuperscript{11}

The quantitative understanding of adiposity in man began in 1942 with the perfection of the hydrostatic method of determining body density. Although hydrostatic weighing involves laboratory equipment and training, it is more accurate than using skinfold measurements for determining external and internal adiposity.\textsuperscript{12}

Allen et al. combined hydrostatic weighing and skinfold calipering, finding that it was impossible to measure both the total and subcutaneous adiposities. They concluded that in lean individuals, adipose tissue was located around organs such as kidneys, in the muscles and in the mesentaries. As a person gained weight, increasing amounts of adipose were found under the skin, hence the round appearance. Fat people had more internal fat, as well as external fat, than thin people. In obese subjects, two-thirds of the fat was located just


\textsuperscript{12}Ibid.
beneath the skin. According to Allen, persons should have no more than one-third of their adipose tissue (29% adiposity) under the skin. A curvilinear relationship was found to exist between the subcutaneous and internal adipose tissue. 13

In 1962 Howell et al. compared specific gravity measures with varying conditions of lung inflation in males. It was determined that even under conditions of maximal lung inhalation, some subjects were still "sinkers." There were low correlations between all buoyancy variables. 14

Steinkamp et al. calculated total body fat from the combined measurements of body density (gas dilution principle) and of total body water (using tritiated water). The error magnitude was found to be ± 0.7 per cent of total body weight. Lean body mass was determined from body weight less total body fat. 15

Measurement of total body water using antipyrine or tritiated water was used in Fletcher's study. Tritium was injected intravenously and the tritium content of the plasma water was measured two hours


later. It was found that changes in hydration had very little effect on adiposity. 16

Lesser, Deutsch and Markofsky conducted a study using measured uptake of the highly fat soluble inert gas, cyclopropane which provided values for the total fat mass and for fat free mass. Body fat and fat-free masses can be measured in this manner without concern as to differing conditions of age, sex and health. They found that there was a need to reinvestigate the overweight population in order to characterize the tissue components associated with increased disease risk. 17

Through comparison of different techniques Steinkamp et al. concluded that the most accurate measurement of body fat was the combined total body water-body density technique. The standard error for fat measurement by this method was \(+1.7\) per cent of total body weight. In addition, fewer assumptions of body composition relationships are necessary with this combined technique than are required for other techniques in determining adiposity. 18

\[\text{\footnotesize 16} \text{ Ronald F. Fletcher, } \textit{Clinical Science}, \text{ pp. 333-346.}\]

\[\text{\footnotesize 17} \text{ Gerson T. Lesser, Stanley Deutsch and Jules Markofsky, "Use of Independent Measurement of Body Fat to Evaluate Overweight and Underweight," } \textit{Metabolism}, \text{ Volume 20, Number 8, (Aug. 1971), 792-804.}\]

Guidelines for Functional Capacity Testing:

Reliability of Testing Procedures and Related Research

Conditioning programs contribute to an increase in functional capacity. Decrease in resting pulse rate, blood pressure, minute ventilation, serum cholesterol and triglyceride concentration are associated with increased work capacity. There is much evidence that exercise is valuable as a preventative and therapeutic measure.¹⁹

Functional capacity is proportional to body weight and is related to lean muscle mass. It is dependent upon the capacity of the body to supply oxygen to the working muscles, and is usually greater in men than in women, as well as greater in active than in sedentary individuals. Functional capacity declines with age, but the rate of decline is much slower in persons who are active physically.²⁰

In recent years, the concept of the MET has gained popularity as a basis for discussion of functional capacity or physical fitness. Oxygen consumption (VO₂) is expressed in milliliters per kilogram of body weight per minute (ml/kg/min.) and one MET is equivalent to


²⁰ Robert A. Bruce, M.D., "Physiology and Medical Aspects of Cardiac Rehabilitation," Needs and Opportunities for Rehabilitating the Cardiac Heart Disease Patient, Report on the Task Force on Cardiovascular Rehabilitation of the National Heart and Lung Association, DHEW Publication Number (NIH) 75-750, (1975), 87-93.
3.5 ml/kg/min. The Appendix, Table 1, contains a chart of METS Cardiovascular Endurance Classification. Reliable field tests, as well as laboratory procedures, have been developed which correlate highly with the distance a person can run and the volume of oxygen consumed.

There are numerous methods used to test functional capacity. All of them were not discussed in this review. Those discussed were: the PWC-170 Test, the Astrand-Rhyming Nomogram, the Harvard Step Test, the Progressive Pulse Ratio Test, Cooper's Twelve Minute Run, Balke's Ten and Fifteen Minute Endurance Run, Bicycle Ergometer, and the Discontinuous or Continuous Standard Motorized Treadmill Test.  

The PWC-170 Test consists of two consecutive 6-minute bicycle ergometer rides in which the workload is set to produce a heart rate of 170 beats per minute. The functional capacity is calculated by plotting the workload against the heartrate. It was found to have a standard error of prediction for VO\textsubscript{2 max} ± 9.47%.  

\[ \text{A study} \]

\[ \text{21 Herbert A. deVries, Physiology of Exercise for Physical Education and Athletics, pp. 204-213.} \]

\[ \text{22 John Naughton, M.D. and Herman K. Hellerstein, M.D., Exercise Testing and Exercise Training in Coronary Heart Disease, (1973), pp. 45-61.} \]

\[ \text{23 Herbert A. deVries, Physiology of Exercise for Physical Education and Athletics, pp. 204-213.} \]
completed by Wojtczeck-Jaroszowa and Banaszkiewicz testing physical work capacity, found that it was higher in the day than at night. Their subjects were athletes, age 16-28 years. 24

Wendelin et al. utilizing the PWC-170 ergometer test, found that changes in fitness occur during the year among university medical and dental students. Increased values were observed during the term and after the summer holidays. During other holidays, fitness decreased. 25

The Astrand-Ryhming Nomogram utilizes the same principal as the PWC-170 Test. The workload is set at 50% maximal and the heart-rate for good functional capacity is predicted by submaximal testing. A nomogram was developed to determine the level of functional capacity by the heart rate of the individual. It has proved to be a very usable method for a small group; however, its prediction reliability is less with unconditioned sedentary subjects. 26

Vuori et al. used the Astrand-Ryhming Nomogram to predict the physical fitness of university students in Finland. They found that


26 Herbert A. deVries, Physiology of Exercise for Physical Education and Athletics. pp. 204-213.
60.1 per cent of the females have a maximal oxygen uptake under the average values as predicted by Astrand's classification. This is probably caused by a lack of exercise and low physical fitness. 27

In a study by Hermansen and Andersen, the ergometer was used to measure maximal oxygen uptake by 2 or 3 submaximal work loads and 1 or 2 maximal workloads on athletes and nonathletes. They recorded higher values for oxygen uptake during bicycling at submaximal rates in athletically trained subjects and lower values in women than in men. The difference in sex was more pronounced among athletes than sedentary individuals. The athletically trained had lower heart rates than sedentary individuals. Sedentary females had the highest maximum heart rate. Heart rate was related to fitness, fit subjects having lower maximal heart rates. They also found that excellence in a particular skill did not guarantee a greater ability to perform exercise with less use of energy. 28

Another similar study by Pugh compared women alpine skiers with laboratory workers using the bicycle ergometer. It was found that


the alpine skiers scored higher than the laboratory workers. The respiratory frequencies were lower in the skiers than the technicians.  

The Harvard Step Test developed by Brouha utilizes heart rate recovery after exercise as a determination of functional capacity. It is the most widely used test because it is easy to administer to large groups. The subjects step up and down a bench that is eighteen to twenty inches high and eighteen inches deep (a bleacher bench is often used) at 30 steps per minute for five minutes or until exhaustion. The observer takes the carotid pulse rate one to one and a half minutes after the exercise has terminated. The error of prediction of maximal oxygen consumption is $\pm 12.5\%$.

Using a modified form of the Harvard Step Test (18 inch bench, stepping rate of 24 steps per minute for 3 minutes), Skubic and Hodgkins found that using their testing method was both reliable and valid and that it clearly differentiated among females who were highly trained, those who were moderately active and those who were sedentary.

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30 Herbert A. deVries, *Physiology of Exercise for Physical Education and Athletics*, pp. 209-211.

They also concluded that age was not a valid factor in the step test among females of junior high school, high school and college age.  

Hodgkins and Skubic drew a larger sample, using 2,360 college women from 66 colleges and universities and asked selected instructors to administer the modified Harvard Step Test as previously described. It was found that subjects from the Eastern AAHPER district of the United States were better than the others and that the physical education majors scored higher than majors in other departments. Overall the cardiovascular efficiency of the students was considered to be fair.

Using a progressive step test, it was concluded that there was a general absence of influence of sports and gymnastics in measurements of fitness in older females. This was due to the fact that a very high portion of time doing these exercises was spent at a low level of cardio-respiratory work. The majority of the subjects were obese.

Ishiko, utilizing the ergometer and the Harvard Step Test, discovered that long distance runners have a better aerobic capacity

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and better general fitness index than other athletes. He also found that vital capacity was not an accurate index of fitness.  

There are conflicting opinions concerning the reliability of the step test as a means of assessing functional capacity. In an editorial in The Canadian Medical Association Journal (1966) the step test is recommended as an easy, reliable way to assess physical fitness. 36

On the other hand, in 1970, The Journal of Sports Medicine published an article which stated that although the step test and variations of it are widely used (at differing workloads and not taking into consideration body weight), there needs to be a standardization of testing methods. 37

The Progressive Pulse Ratio Test is similar to the Harvard Step Test. The bench used is seventeen inches high and there are five one-minute bouts with increasing rates: 12, 18, 24, 30 and 36 steps per minute. After each minute of stepping, the pulse rate is taken for two minutes. The subject then starts on the next bout of stepping. The pulse rates are plotted on a chart where norms have been


established. This test is not as accurate as the Harvard Step Test. It is, however, easier on the subject and less muscle soreness is involved.  

Cooper's 12-Minute Run measures the distance the subject runs as an indicator of his functional capacity. There are separate charts for men and women and age is also a considered factor. The distances have been predetermined through numerous testings.

Balke's 10 and 15 Minute Endurance Run also measure the distance ran as an indication of functional capacity. In addition, Balke's chart lists the amount of oxygen consumed per unit of time and is expressed in milliliters per kilogram of body weight. The Balke Tests are reliable indications of functional capacity and are easy to administer to a large group. The MET concept can be employed in this test as well as Coopers.

The motorized treadmill provides the work intensity for the subject by maintaining a pre-set speed. It is advantageous in that it uses a skill with which everyone is familiar—walking or running. The

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38 Herbert A. deVries, Physiology of Exercise for Physical Education and Athletics, pp. 211-213.

39 Kenneth H. Cooper, M. D., Aerobics (1968)

40 Robert A. Bruce, M. D., Needs and Opportunities for Rehabilitating the Cardiac Heart Disease Patient, p. 88.

speed and incline are adjustable. It is an accurate method of determining functional capacity, which in this test can be measured in METS. 42, 43

Basically, there are two types of exercise-testing procedures. 44 One is submaximal, with one or more workloads, performed either with or without intermittent rest periods. Using the treadmill, an example of this would be a graded treadmill test. It is the most reproducible at 3 mph and 5 percent grade of incline. 45 The other procedure is maximal exercise testing, which is individually determined after progressive increments in workload, or multistage treadmill test. The individual works to his maximal toleration limit. When this is attained, the intensity and duration of the effort, heart rate, oxygen intake and blood pressure are observed to help define the limits of the individual. Higher levels of oxygen intake, heart rate and lactate have been recorded with a treadmill than with either the bicycle ergometer or step-test methods. 46

42 Herbert A. deVries, Physiology of Exercise for Physical Education and Athletics, pp. 146-148.

43 Robert A. Bruce, M.D., Needs and Opportunities for Rehabilitating the Cardiac Heart Disease Patient, p. 88.


45 Robert A. Bruce, M.D., Exercise Testing and Exercise Training in Coronary Heart Disease, p. 48.

46 Robert A. Bruce, M.D., Exercise Testing and Exercise Training in Coronary Heart Disease, pp. 47-48.
Hermansen and Saltin compared oxygen uptake running uphill on the treadmill, with the bicycle ergometer uptake in 55 healthy male subjects (19-68 years). The oxygen uptake on the treadmill was \( 0.28 \) liters higher. \(^47\)

In a study of responses to maximal exercise of 144 healthy middle aged women, Profant et al. discovered that the maximal heart rate was identical for active and sedentary women. However, the active women had a higher maximal oxygen uptake. \(^48\)

Using 19 subjects, Garrett et al. determined the reproductivity of various physical fitness tests. They concluded that submaximal tests were less reproducible and that maximal treadmill tests had a high degree of reproducibility. \(^49\)

Twenty young adult males were used to compare a continuous and discontinuous graded treadmill test for maximal oxygen uptake. No significant differences were found in maximal oxygen uptake. It was concluded that it was easier to administer the continuous test.


because only one visit to the laboratory was necessary. Whereas at least three visits were required for the discontinuous test. Hanne-Paparo concluded that as of yet no single test for functional capacity has been universally accepted. She also mentioned that any fitness test should include the measurement of maximum oxygen consumption, if it is to be considered valid or worthwhile.

Related Literature Pertaining to Adiposity and Functional Capacity

Numerous studies have been conducted to determine if a relationship exists between adiposity and functional capacity. In addition, various components of adiposity and functional capacity have been studied in an effort to relate them to age, extreme obesity, body composition, ethnic background, history of physical activity and psychological problems. Results of these research efforts were compiled and are presented in this section.

In discussing the principles of exercise testing, Bruce mentions that in healthy persons, maximal oxygen consumption varies directly with body weight, especially lean body mass and it is higher in athletes


than in sedentary persons. 52 In an editorial in Circulation, it was concluded that maximal oxygen consumption was closely correlated with lean body weight and active tissue. 53 Hodgkins and Skubic also found that women who weighed 150 pounds or more did not score as well in the step test as those who weighed less. 54 Being overweight has been shown to be detrimental to step test performance. 55 To further support these findings, Teraslinna et al. studied 44 subjects ages (23-54) to determine the relationship between physical fitness and susceptibility to cardiovascular disease. They found that there was a detrimental effect of weight on motor performance in the bicycle ergometer test.

While researching the relationships of nutrition, body fat and physical fitness, Parizkova determined that the degree of physical activity and fitness had a relationship to some pathological conditions.

52 Robert A. Bruce, M.D., Exercise Testing and Exercise Training in Coronary Heart Disease, p. 51.


involving fat metabolism. Fit individuals had a lower percentage of fat, more lean muscle mass and remained at a constant weight, whereas unfit and overweight individuals were lacking in these areas. Hermansen et al. also found that those women who were athletically trained had more lean muscle mass than those who were not active.

It has been determined that age inversely affects functional capacity. Yet active participation in physical activities delays the decline in aerobic capacity that occurs between ages 20 and 60. Bell and Hinson used performance times in the 440 yd and 880 yd runs to test 30 women. They ranged in age from 20 to 40, and included sedentary housewives and secretaries as well as moderately active women. They discovered that there was a correlation between maximal oxygen consumption and age.

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59 Robert A. Bruce, Exercise Testing and Exercise Training in Coronary Heart Disease, p. 51.

60 G. R. Cumming, Circulation, p. 5


Carver and Winsmann tested 149 Special Forces soldiers, ages 19-39, to find if there was a significant relationship between age and physical work performance. They found that the decline in 19-30 years of age was relatively consistent and that in the 30-39 age bracket there was less consistency.  

L. E. Bottiger studied maximal ski performance in relation to age. He found that although in a normal population age would have detrimentally affected performance, the best competitors were aged 31-35 years. He concluded:

The fact that the physical working capacity of the average population falls with age does not imply that older individuals cannot occasionally retain a physical working capacity which is good--or even better--than that of younger persons.  

In an effort to determine the prevalence of obesity in the British Army among 18 and 19 year old recruits, Crowdy and Vogel conducted a study of 254 recruits. They discovered that compared to previous recruits there was an increase in adiposity among the young men.

For eleven years (1958-1969), Mocellin et al. studied a population of 102 children, ranging in age from 8 to 18 years to determine the

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65 J. P. Crowdy and J. A. Vogel, "Obesity and Physical Fitness in the British Army," _Clinical Science of Molecular Medicine_, Vol. 45 (Sep. 73), 10p-11p.
relationship of obesity to physical working capacity. They found that with increasing obesity physical working capacity decreases. The boys and girls who were 40% overweight or more displayed a physical working capacity under the standard deviation level.66

In a study of 16 extremely obese adult patients' (238 kg and above) initial work tolerance, Foss et al. found that their progress was mainly due to motivational factors and not due to percent adiposity. He found that they were very juvenile in their actions and had to be constantly reinforced.67 Bar-Or et al., studied the effect of heat stress on four lean women (less than 18% adiposity) and five obese women (more than 23% fat) while walking at 3 m.p.h. at 5% grade. These obese women were less tolerant to the heat stress than the leaner subjects.68

Garrity discovered that structural differences in women were related to their performance in physical fitness tests. She tested 202 college women and somatopyped each one according to individual photographs. She found that the ectomorph-endomorph group scored


consistently low in all test items. The mesomorph-ectomorph group performed the physical fitness tests more efficiently than the others. Coger and Macnab also compared body composition and work capacity in 40 participants and 40 nonparticipants in sports. They concluded that the participant group was taller, heavier and had more lean body-mass as well as more body fat than the nonparticipants. However, the participants had significantly lower thigh fat measurements than the nonparticipants. Using the Harvard Step Test, McGuinness and Sloan compared dynamic fitness to physical training and body fat in 148 student teachers, ranging in age from 18-25 years. They found that while the women physical education students were fitter than the others, they had more body fat than the other women. The moderately active women were lighter and more slender, as well as more fit than the sedentary women.

Taguchi et al. classified 45 healthy females, ages 17 to 34 years, into 3 groups according to ethnic origin and generation in a


particular environment. These groups were Japanese-born residents of California, third generation Japanese-Americans and Caucasians.

To compare their aerobic capacity, they were tested on a modified Balke-treadmill test. It was discovered that there were no differences between the second and third generation Japanese-Americans. However, the Caucasians were more physically active and therefore scored better on the test. This difference was mainly due to environmental factors, Caucasians being inherently more active. 72

It was discovered that physically fit women complained less about menstrual discomforts, had less backaches, digestive disorders, fatigue, colds, allergies and headaches than less fit women. 73 However, it takes motivation to be consistently physically active. This may be dependent on age, personality, level of aspiration, the complexity of the task as well as the specificity of the task. 74, 75


person becomes motivated enough to pursue a fitness program, only to become discouraged after learning that it requires discipline and regularity.
CHAPTER III
MATERIALS AND METHODS

A review of the related literature has suggested that the use of methods of measurement in this study are some of the most reliable. In addition, the facilities and equipment necessary for utilization of these tests were readily available to the researcher. The tests used in this study were chosen on the basis of this concern. Adiposity was determined using two methods, skinfold measurements and hydrostatic weighing. Two methods were compared to determine their correlation. Functional capacity was measured using a Balke Continuous Multistage Graded Treadmill Test.

Subjects

The subjects for this study were 60 women, ages 18-39, attending physical education activity classes at Utah State University, Logan, Utah during winter and spring quarters 1976. All of the participants in this study were volunteers. Only a small number were physical education majors.
Methodology

The subjects reported to the Human Performance Research Center at Utah State University between the hours of 3:30 PM and 9:00 PM, each having a scheduled testing time of 40 minutes. The room air temperature was set at 68°, and each subject was previously instructed to wear gym clothes, tennis shoes and to bring a swim suit and towel. Instructions were given to each subject prior to the actual testing to eliminate anxiety. Minimal conversation was maintained between subject, laboratory assistant and researchers. Laboratory assistants were physical education majors provided by undergraduate Physiology classes and were trained by the researcher.

Personal data (age, frequency of exercise/times weekly, height and weight on a calibrated scale) were obtained first, by the laboratory assistant. Skinfold measurements were recorded next by the researcher. With the subject standing, resting blood pressure and heart rate were recorded prior to the Continuous Multistage Graded Treadmill Test. The subject mounted the treadmill, which was set at a brisk walking speed of 3 m.p.h. Testing commenced when the subject signaled that she was ready. Blood pressure and heart rate were recorded each minute of the testing and recovery periods by the researcher. The subjects then changed into swim suits and after measuring total lung capacity and residual volume using the helium dilution method, were hydrostatically weighed.
A pilot study was conducted to insure accurate application of the testing procedures and also to determine the time involved per subject. The pilot study was necessary to familiarize the researcher with the methods and procedures involved in this research and to identify any problems that could have arisen during testing.

The statistical design used was the Statistical Package for the Social Sciences (SPSS).

**Adiposity from Skinfold Measurements**

Weight and height were measured on a Healthometer medical scale. Body surface area was then determined using a Dubois Body Surface chart. Adiposity was measured using Lange skinfold calipers. A skinfold was lifted up between the thumb and forefinger. The skinfold calipers were applied 1-2 cm. above the fingers. The reading of the caliper was taken after the movement of the needle that registered the measurement stopped. The measurements were made in millimeters and were taken from ten sites on the body.

1. left cheek
2. under the chin on the upper part of the throat
3. back of the left upper arm, triceps area
4. chest, four inches above the left nipple
5. back, inferior angle of the left scapula

---

1 Dubois Body Surface Chart, as prepared by Boothby and Sandeford of the Mayo Clinic, Warren E. Collins, Inc.
6. middle of the left side
7. two inches above the left iliac crest
8. abdomen, left side of the naval
9. above the left patella
10. back of the lower left leg, near the knee

The measurements were totaled. The following formula was used to compute percentage fat.

\[
\text{Adiposity (A)} = MA \sqrt{\frac{S_f \times S_{20} \times .739}{MA}} - 0.0030
\]

Where:

\( MA \) = mass in air kg.

\( S_f \) = Total 10 skinfolds, -40 mm

\( S_{20} \) = Body surface area

For methods of recording see the Appendix, Table 2.

**Functional Capacity**

Prior to the treadmill test, resting heart rate and blood pressure were taken with a conventional blood pressure cuff, with the subject standing. The cuff was secured with masking tape and remained on the subject's left arm throughout testing. Each subject was permitted to acquaint herself with the operations of the treadmill before actual testing.
For the first minute, the elevation of the treadmill was 2.5%, it was elevated 2.5% each additional minute of testing. At the end of 8 minutes, the elevation was 20% and remained there until the subject was finished. The speed of the treadmill was set at 3 mph (a brisk walk) for the first 8 minutes, it was then raised 0.25 mph each additional minute the subject remained on the treadmill. Blood pressure and heart rate were recorded each minute the subject was being tested. Each subject performed to her maximal capacity and stopped only when she felt she could not continue. After completion of test the treadmill's workload was set at 0% grade, 1.5 mph and the subject's recovery heart rate and blood pressure were recorded for 3 minutes. All readings were taken by the researcher and recorded by the laboratory assistant.

Treadmill METS is determined in two steps. Maximal oxygen consumption ($\dot{V}O_2$) at the highest workload attained is calculated in the following formula.

$$\dot{V}O_2 = (\text{vel. m/min. } \times 1.78) \left(\frac{\% \text{ grade} + 7.3}{100}\right)$$

As explained earlier 1 MET = 3.5 ml/kg/min. The MET load is determined by dividing 3.5 into the maximal oxygen consumption ($\dot{V}O_2$) attained by the individual. Hence:

$$\text{METS} = \frac{\dot{V}O_2}{3.5}$$

For methods of recording see the Appendix, Table 3.
Vital Capacity, Residual Volume and Total Lung Capacity

Vital capacity (V. C.) was measured using a regular Collins 13.5 liter spirometer. A mouth piece and nose clip set up was used. The subject inhaled room air and exhaled maximally into the spirometer. This was done three times for accuracy and recorded by the researcher each time. The results were cross-checked using Baldwin, Cournand and Richards "Predicted Vital Capacity, Females,"\(^2\)

Residual Volume (R. V.) was measured by the helium closed-circuit method. The helium closed-circuit system consisted of a Collins helium catharometer (helium analysis meter) attached to the Collins 13.5 liter spirometer with a blower, which was set at a speed of 10-30 liters per minute. The blower pumped the sample through the helium meter. Soda lime was used to absorb carbon dioxide.

A measured amount of helium (600 milliliters) was introduced into the bell. The blower was turned on to the "predetermined speed" and when the helium reading stabilized, the first reading \((C_1)\) was recorded. With the blower off, one liter of air was quickly added. A second reading \((C_2)\) on the helium meter, with the blower running and equilibrium established, was recorded. A mouth piece and nose clip set up was used with the subject sitting and at the end of the normal expiration, the subject was turned on to the helium-air mixture.

During the period of breathing, an oxygen flow (at a rate of about 250 milliliters/minute) was added and adjusted to maintain a reasonably horizontal base line on the kymograph paper. When the helium reading no longer changed (± 0.03%) usually about 2-3 minutes or at the end of 7-minutes, the helium concentration ($C_3$) was recorded. Three maximal expiratory maneuvers were performed without prior inspiratory effort, and recorded on the kymograph paper.

The calculations were as follows:

Recorded:
- $C_1$ = First Helium Reading (after He added)
- $C_2$ = Second Helium Reading (after air added)
- $C_3$ = Third Helium Reading (after equilibration)

Total Volume = Volume air added between $C_1$ and $C_2$

ERV = Expiratory Reserve Volume from end of spirogram

BTPS = Tractor (body temperature and pressure saturated with water vapor)

The formula for Functional Residual Capacity (FRC) was:

$$F.R.C. = \frac{\text{Total Volume} \times \frac{\text{Initial } H_2 \text{ reading} - \text{final } H_2 \text{ reading}}{\text{final } H_2 \text{ reading}}}{100}$$

After F.R.C. was calculated, 100 cc was subtracted to compensate for the helium left in the tissues and blood stream after testing. Functional Residual Capacity was then corrected for the BTPS factor. To
obtain the Residual Volume (R. V.), Expiratory Reserve Volume (ERV) was corrected for the BTPS factor and the following formula was used\[^3,4\]

\[ R. V. = F. R. C. - E. R. V. \]

These results were cross checked using the "V.A. - Army Cooperative Study Prediction Nomogram for Normal Men (BTPS)," with allowances made for women.\(^5\)

Total Lung Capacity (T. L. C.) was obtained by adding the Residual Volume (R. V) to the Vital Capacity (V. C).

Hence:

\[ T. L. C. = R. V. + V. C. \]

The results were cross checked by two methods. The first method was used to correct for residual volume without the helium washout measurement. The Vital Capacity was multiplied by 0.250 and added to the Vital Capacity, as follows:

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T. L. C. = V. C. (0.250) + V. C.

The second cross check used was the "Prediction Nomogram" developed by the Army.

Adiposity from Hydrostatic Weighing

Each subject was weighed out of the water on a Health O Meter medical scale and their height and weight were recorded ($M_A$). The dry weight of the swim suit was estimated at 0.25 lb (Dry Tare). The Residual Volume of air in the lungs (R. V.) was measured and cross checked using the techniques described earlier. The nose clip and mouth piece set up was used to prevent leakage of air. While in a small tank of water, the subject exhaled half of her Total Lung Capacity into the spirometer bell, as determined by pre-tested Vital Capacity, and was weighed while totally submerged. The wet weight ($M_W$) was recorded three times for accuracy by the researcher. To accurately determine body density (Db), it was necessary to subtract the weight of the chair (Wet Tare) from the wet weight. The formula used to determine body density was the formula developed by Brozek.

$$Db = \frac{MA}{MA - MW} - (R.\ V. + V.\ G.\ I.)$$

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Percent of adiposity was then calculated as follows:

\[
\% \text{ Adiposity} = \frac{ Db }{ 4.570 } - 4.142 \times 100
\]

Where:

\[ M_A = \text{mass in air kg.} \]
\[ R_V = \text{Residual Volume} \]
\[ M_W = \text{mass in water} \]
\[ D = \text{body density} \]
\[ D_W = \text{water density correction factor} \]
\[ V_G I = \text{volume of gas in the intestinal tract-115} \]

This formula was on computer file at the Utah State University Computer Center. The computer program was utilized by this researcher to insure accuracy of the calculations.

A copy of the recording methods for lung volume determinations and hydrostatic weighing is located in the Appendix, Table 4.

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CHAPTER IV

RESULTS

The purpose of this study was to test whether a relationship existed between the dependent variable adiposity and the independent variable functional capacity. The other independent variables that were included in testing were; age, height, weight, frequency of exercise, fat free weight, lung capacity and blood pressure. See Table 5 in the Appendix for collective data. The statistical design was the Statistical Package for the Social Sciences and the results were categorized by using Albert E. Bartz's test for statistics.\(^1\) A multiple regression equation using selected independent variables is presented as an alternate method for determining adiposity.

Collective Data

In this study, adiposity by the hydrostatic method and METS (functional capacity--\(\dot{V}O_2_{\text{max}}\)) had a moderate negative correlation coefficient of \(r = -0.4706\). See Figure 1. Age and METS had a low negative correlation coefficient of \(r = -0.2116\). Due to the similarity in height a zero correlation (\(r = -0.0284\)) was found with METS. Weight

Figure 1. Correlation of METS and adiposity as determined by the hydrostatic method.
and METS also had a low negative correlation coefficient of \( r = -0.3427 \).

Fat-free weight and METS had a zero correlation of \( r = -0.0565 \). In this group, lung capacity and METS had a low correlation coefficient of \( r = 0.3278 \). Resting blood pressure was negatively correlated with METS with a low \( r = -0.1568 \).

Of the nine variables studied, weight showed a very high correlation with the percentage of adiposity as determined by skinfold measurements, \( r = 0.8418 \). See Figure 2 for scattergram.

As expected, fat free weight was strongly correlated with weight, \( r = 0.7897 \). Total lung capacity and fat free weight were moderately correlated \( r = 0.5566 \).

The mean percentage of adiposity (average of skinfold and hydrostatic method) had a moderate negative correlation with the frequency of exercise, \( r = -0.4203 \). Adiposity as determined by the hydrostatic method was also moderately negatively correlated with lung capacity, \( r = -0.4476 \).

**Multiple Regression Equation**

The multiple regression equation predicting the dependent variable adiposity by skinfold when the four independent variables are known. By squaring the correlation coefficient \( r^2 \) the statistical
Figure 2. Correlation of weight and adiposity as determined by the skinfold method.
significance of the predicted adiposity can be expressed as a percentage. In this instance $r = 0.89554$ which is very high and $r^2 = 0.80200$, meaning that 80% of the variation in adiposity is explained by the four independent variables included in the multiple regression equation. Following is the multiple regression equation for prediction of adiposity by skinfold.

Percentage of adiposity by skinfold = $A_s$

\[ A_s = -0.96925 + 0.71987 \text{ (weight, kg)} - 0.14981 \text{ (height, cm)} - 2.09372 \text{ (lung capacity)} + 0.10994 \text{ (systolic blood pressure)} \]
CHAPTER V
DISCUSSION

The purpose of this study was to test whether a relationship existed between adiposity and functional capacity. A moderate negative correlation of $r = -0.4706$ was found, indicating that as the percentage of fat increases, a person's functional capacity, or $\dot{V}O_2\max$ decreases. With an adiposity of $\bar{X} = 22.2\%$ these subjects were considerably above what Bar-Or et al classified as lean (less than $18\%$ adiposity).\(^1\) This could possibly explain the very low METS level of $\bar{X} = 10.9$ or $38.3$ ml/kg/min. The subject that had the highest adiposity ($39.7\%$, by the hydrostatic method) and was obese by Bar Or's standards also had the lowest $\dot{V}O_2\max$ (28 ml/kg/min or 8 METS), which is very poor for a woman of 23 years of age. The subject with the highest $\dot{V}O_2\max$ (59.5 ml/kg/min or 17 METS) which is excellent for a woman of 26 years, had an adiposity of $18\%$, which is lean. If this study were truly a random sample with more very obese and very lean subjects, the correlation between METS and adiposity probably would have been higher. As evidenced by examining the extremes in each category, the correlation is more apparent. Much research has been done to substantiate the

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very high correlation between adiposity and functional capacity, in random sample populations.  

Bell and Hinson and others found that age inversely affects functional capacity. In this study, there was a very low negative correlation between METS and age \( r = -0.2116 \). This could be due to the small range in ages, the majority ranging between 18 and 20 years. The youngest subjects (9 women, 18 years) had a MET level of \( \bar{X} = 11 \) or 38.5 ml/kg/min which is good. The oldest subject (39 years) had a very poor \( \dot{V}O_2 \text{max} \) (28 ml/kg/min or 8 METS). Again, research using a truly random sample would probably reveal that as age increases \( \dot{V}O_2 \text{max} \) decreases. This is evidenced when studying the extremes in this study, and in other research.

Examination of the means in this study of weight and METS show a low negative correlation of \( r = -0.3427 \). However, the heaviest subject (85.9 kg) also had the lowest \( \dot{V}O_2 \text{max} \) (28 ml/kg/min or 8 METS). The lightest subject (44.1 kg) had a good \( \dot{V}O_2 \text{max} \) of 38.5 or 11 METS. If more very heavy and very light subjects had been tested,

\[ R. \text{Macellin and J. Ruthenfranz, } \text{Acta Paediatr Scandinavica [suppl], pp. 77-79.} \]

\[ H. \text{Marie Garrity, } \text{The Research Quarterly, pp. 340-352.} \]

\[ \text{Alice C. Bell, Ph. D. and Marilyn M. Hinson, Ph. D., Journal of Sports Medicine, pp. 208-212.} \]

\[ R. \text{P. Carver and F. R. Winemann, Ergonomics, pp. 247-253.} \]
the results would probably have more closely reflected what other researchers have found. Hodgkins and Skubic and others found that women who weighed 68 kg or more did not score as well in the step test as those who weighed less. Teraslinna et al. also found weight to be detrimental in the bicycle ergometer test. While this is not a step or bicycle ergometer test, weight plays an important part in the later stages of the testing.

The zero correlations of height and METS and fat-free weight and METS change very little when looking at the extremes in this study. The tallest subject (180 cm) had a \( \dot{V}O_2 \) max of 35 ml/kg/min or 10 METS, which is fair, and the shortest subject (130 cm) had a \( \dot{V}O_2 \) max of 42 ml/kg/min or 12 METS, which is good. The subject with the highest fat free weight (64 kg) had a \( \dot{V}O_2 \) max of 38.5 ml/kg/min or 11 METS. The lowest fat free weight was 34.1 kg and this subject also had a \( \dot{V}O_2 \) max of 38.5 ml/kg/min or 11 METS.

The low correlation between METS and total lung capacity (r = 0.3278) again could be due to the lack of a random sample. The


The smallest total lung capacity was 2.4 liters and this subject had a \( \dot{V}O_2 \) max of 28 ml/kg/min or 8 METS, which is very poor. The largest total lung capacity was 5.4 liters and the \( \dot{V}O_2 \) max was 42 ml/kg/min or 12 METS, which is good. The subject with the highest \( \dot{V}O_2 \) max (59.5 ml/kg/min or 17 METS) had a total lung capacity of 5.25 liters. This indicates that as functional capacity increases, total lung capacity should also increase. One of the effects of cardiovascular training is that the lungs become more efficient in handling oxygen as well as increase in volume.

Upon examination of the extremes in resting blood pressure (95/40 and 132/89) and their corresponding METS levels (13 METS or 45.5 ml/kg/min and 9 METS or 31.5 ml/kg/min), a possible negative correlation becomes apparent. The means of these two variables show a low negative correlation, \( r = -0.1568 \). If a random sample were studied, possibly it would be more evident that as resting blood pressure increased, \( \dot{V}O_2 \) max would also decrease.

In these subjects, as weight increased so did the skinfold measurements for adiposity \( (r = 0.8418) \). This probably would not happen if the population studied was trained athletes. Muscle mass weighs more than adipose tissue and some athletes are notorious for their lack of adipose tissue and high weights (wrestlers). Examination of the extremes in both categories reveal that the heaviest subject \( (85.9 \text{ kg}) \) also had the highest percentage skinfold adiposity \( (45.9\%) \).
However, the lightest subject (44.1 kg) had a skinfold adiposity of 14%. Yet the lowest skinfold adiposity was 8% and that subject weighed 50 kg. Nevertheless, a relationship is apparent.

A look at the extremes does substantiate the strong correlation between weight and fat free weight \((r = 0.7897)\). The subject that was heaviest (85.9 kg) had a fat free weight of 50.4 kg. The subject with the highest fat free weight (64 kg) weighed 84 kg. The lightest subject (50 kg) had a fat free weight of 41.0, and the lowest fat free weight was 34.1 with a weight of 52.7. This shows that in this population, as the weight increased, so did the fat free weight. Had the subjects been athletes, the correlation probably would have been higher.

The moderate correlation between total lung capacity and fat free weight \((r = 0.5566)\) shows that as fat free weight increases, total lung capacity also increases. This is due to the training effect of exercise. As one exercises, the muscle mass increases as well as the efficiency of volume of the lungs.\(^9\)

The moderate negative correlation \((r = -0.4203)\) between adiposity and frequency of exercise indicates that as frequency of exercise increases adiposity decreases. This correlation would have been higher if there had been more athletes in the population.\(^{10}\)

\(^9\) Robert A. Bruce, M. D. Exercise Testing and Exercise Training in Coronary Heart Disease, p. 51.

\(^{10}\) Jana Parizkova, M.D., Ph. D., Bordon Review of Nutrition Research pp. 41-54.
were very few athletes in this study and those that were, did have lower adiposity, and exercised more frequently than those who were not athletes. The subject with the highest adiposity (39.7%) had no weekly exercise, whereas the subject with the lowest adiposity (9.6) exercised 6 times per week.

As total lung capacity increased, adiposity decreased ($r = -0.4476$). This is especially evident when looking at the extremes of the study. The largest total lung capacity was 5.4 liters and this subject's adiposity was also the lowest at 9.6%. The subject with the smallest total lung capacity (2.4) was also the highest in adiposity, 39.7%. As explained earlier, total lung capacity increases with cardiovascular training and adiposity also decreases with training.

**Summary**

The purpose of this study was to test whether a relationship exists between adiposity and functional capacity. A moderate negative correlation was found between adiposity and functional capacity. This indicates that as adiposity increases, functional capacity decreases.

**Recommendations**

It is strongly recommended that further research be done in this area using a large random sample of women or men. It would also be advisable to divide the sample population into different categories of
adiposity and run the same tests. This researcher feels that these testing procedures were excellent and would recommend the same tests be used for further research in this area.
SELECTED BIBLIOGRAPHY


Cooper, Kenneth H., M.D. Aerobics (1968)


Table 1. METS Cardiovascular Endurance Classification

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<th>30-40</th>
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<td>Men</td>
<td>Women</td>
</tr>
<tr>
<td>I. Very Poor</td>
<td>under 8.50</td>
<td>under 8.12</td>
</tr>
<tr>
<td>II. Poor</td>
<td>8.50-10.30</td>
<td>8.12-9.55</td>
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<tr>
<td>IV. Good</td>
<td>12.25-14.05</td>
<td>11.50-13.30</td>
</tr>
<tr>
<td>V. Excellent</td>
<td>14.25 +</td>
<td>13.50 +</td>
</tr>
</tbody>
</table>

Kenneth H. Cooper, *Aerobics, "Cardiovascular Endurance Classification"*
Converted to METS by Lanny J. Nalder, Ph.D.
Table 2. Personal data and adiposity by skinfold

Personal Data:

<table>
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<tr>
<th>Name</th>
<th>Age</th>
<th>Date</th>
<th>Smoking</th>
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</thead>
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<table>
<thead>
<tr>
<th>No. Offspring</th>
<th>Height (in)</th>
<th>Weight (lb)</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

Adiposity by skinfold:

1. cheek
2. chin
3. arm
4. chest
5. back
6. side
7. iliac
8. abdomen
9. knee
10. calf
Total mm.

Body Surface Area sq. m. Weight kg.

% Adiposity
<table>
<thead>
<tr>
<th>NAME_</th>
<th>AGE_</th>
<th>HEIGHT_ cm.</th>
<th>WEIGHT_ kg.</th>
<th>DATE_</th>
</tr>
</thead>
<tbody>
<tr>
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<table>
<thead>
<tr>
<th>TYPE OF TEST</th>
<th>AGE</th>
<th>SPEED</th>
<th>% GRADE</th>
<th>MAXIMUM MET LOAD</th>
<th>DURATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>REST</td>
<td></td>
<td>260+</td>
<td>+ + + +</td>
<td>+ + + + + + + + +</td>
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<tr>
<td>EX.</td>
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<td>250+</td>
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<tr>
<td>REC.</td>
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<td>240+</td>
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<td>TEST</td>
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<tr>
<td></td>
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<tr>
<td></td>
<td>3</td>
<td>210+</td>
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<tr>
<td></td>
<td>4</td>
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<tr>
<td></td>
<td>5</td>
<td>190+</td>
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<tr>
<td></td>
<td>6</td>
<td>180+</td>
<td>+ + + +</td>
<td>+ + + + + + + + +</td>
<td>+ + + + + + + +</td>
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<tr>
<td></td>
<td>7</td>
<td>170+</td>
<td>+ + + +</td>
<td>+ + + + + + + + +</td>
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<tr>
<td></td>
<td>8</td>
<td>160+</td>
<td>+ + + +</td>
<td>+ + + + + + + + +</td>
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<tr>
<td></td>
<td>9</td>
<td>150+</td>
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<tr>
<td></td>
<td>10</td>
<td>140+</td>
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<td>12</td>
<td>120+</td>
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<td>110+</td>
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<tr>
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<td>50+</td>
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</table>

**BLOOD PRESSURE**

<table>
<thead>
<tr>
<th>Min.</th>
<th>Grade %</th>
<th>Blood Press.</th>
<th>HR</th>
<th>Mets</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>KGM</td>
<td>Syst.</td>
<td>Dia.</td>
<td>KGM</td>
</tr>
<tr>
<td>REST</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EX.</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>REC.</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

**HEART RATE**

<table>
<thead>
<tr>
<th>Min.</th>
<th>Heart Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td>3</td>
<td>100</td>
</tr>
</tbody>
</table>

1 Met = 3.5 ml/kg/min

TREADMILL METS DETERMINATION = \( \text{VO}_2 = (\text{vel. m/min} \times 1.78) \times (\% \text{grade} + 7.3) \)

BICYCLE METS DETERMINATION = \( \text{VO}_2 = \frac{\text{KGM} \times 2 + 300}{\text{Bod. Wr. in kg}} \times 100 \) METS = \( \text{VO}_2 \)}
Table 4. Adiposity by hydrostatic, weighing and helium washout

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th></th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Dry weight lbs.</td>
<td>9</td>
<td>C₁</td>
</tr>
<tr>
<td>2</td>
<td>Dry Tare (.25 lbs)</td>
<td>10</td>
<td>C₂</td>
</tr>
<tr>
<td>3</td>
<td>Water Temp. °C</td>
<td>11</td>
<td>C₃</td>
</tr>
<tr>
<td>4</td>
<td>kg Three Wet Weight</td>
<td>12</td>
<td>Total Volume</td>
</tr>
<tr>
<td></td>
<td>kg</td>
<td>13</td>
<td>Expiratory Reserve Volume</td>
</tr>
<tr>
<td></td>
<td>kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>PB Correction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Wet Tare</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Total Lung Capacity</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(liters)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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</tr>
<tr>
<td>8</td>
<td>Expired Volume</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(liters)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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</tr>
</tbody>
</table>

% Adiposity ___________  Fat Free ___________
<table>
<thead>
<tr>
<th>Variables</th>
<th>Subjects</th>
<th>Females N = 60</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Variance</td>
</tr>
<tr>
<td>Age (yrs)</td>
<td>21.2</td>
<td>13.6</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>164.6</td>
<td>67.2</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>60.2</td>
<td>78.3</td>
</tr>
<tr>
<td>Frequency Ex/ Times Weekly</td>
<td>2.4</td>
<td>3.4</td>
</tr>
<tr>
<td>Skinfold - % Adiposity</td>
<td>21.6</td>
<td>49.2</td>
</tr>
<tr>
<td>Hydrostatic - % Adiposity</td>
<td>22.8</td>
<td>42.3</td>
</tr>
<tr>
<td>Hydrostatic Fat Free (Kg)</td>
<td>45.9</td>
<td>43.0</td>
</tr>
<tr>
<td>Skinfold/Hydrostatic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average % Adiposity</td>
<td>22.2</td>
<td>34.5</td>
</tr>
<tr>
<td>Lung Capacity</td>
<td>3.9</td>
<td>0.42</td>
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<tr>
<td>Blood Pressure</td>
<td>110/62</td>
<td>83.7/71.0</td>
</tr>
<tr>
<td>ML/KG/MIN</td>
<td>38.3</td>
<td>33.6</td>
</tr>
<tr>
<td>METS</td>
<td>10.9</td>
<td>2.7</td>
</tr>
</tbody>
</table>
VITA
Barbara P. Gibbs
Candidate for the Degree of
Master of Science

Thesis: The Relationship Between Adiposity and Functional Capacity in 60 Women Attending Utah State University 1975-76

Major Field: Physical Education

Biographical Information:


Education: Attended elementary and junior high school in Hickory Corners, Michigan; graduated from The White Mountain School, Littleton, New Hampshire, 1968; received Bachelor of Arts, California State University, Los Angeles with a major in Art, 1973; did graduate work at University of Utah. Completed requirements for Master of Science with a major in Physical Education at Utah State University, 1976.

Professional Experience: Employed, Teton Valley Ranch, Summer 1969, camp counselor for girls 11-12 years of age; National Outdoor Leadership School, Summer 1970, Survival instructor; University of Utah, Spring 1975, Arts and Crafts teacher; Utah State University, 1975-76, graduate assistant in Physical Education.