ANTHROPOMETRIC MEASUREMENT IN ESTIMATING DESIRABLE BODY WEIGHTS OF SOME FEMALE COLLEGE STUDENTS AT OKLAHOMA STATE UNIVERSITY

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CHAPTER I

INTRODUCTION

It is of great importance to be able to determine a practical method for assessing body weights. In the study of food and how it plays its role in the nourishment of the body, many types of unsatisfactory nutritional states have been determined.

Ancel Keys (35, p. 245) states that :

> The first step in nutritional evaluation is a calorie judgement. Such judgement is only possible if a close prediction of body weight can be made in relation to age, height and frame.

Statement of the Problem

This study is undertaken in an attempt to determine body weights in reference to body frame. Seven skinfold measurements and seven anthropometric measurements were determined for 95 female college students, 18 to 25 years of age. The significance of these measurements in relation to desirable body weight and leanness-fatness will be calculated. Correlations, if any, between various anthropometric measurements, desirable body weight, and body leanness-fatness will be determined.

Anthropometry is the systematized art of expressing quantitatively the form of the body. It is the measurement of man, his skeleton, his brain or other organs, whether living or dead, by the most reliable means and methods for scientific purposes. The essentials of anthropometry and the criterion by which it differs from other biological disciplines is its comparative nature.

According to Brozek (10) nutritional anthropometry refers to the application of body measurements for the purpose of characterizing man's nutriture with emphasis on body composition.

Nevertheless, anthropometry has an important, though limited, contribution to make to the assessment of nutritional status. This has been clearly recognized by the Joint WHO Expert Committee on Nutrition in which Brozek (12, p. 148) stated the following in 1953:

> The physical dimensions of the body are therefore of importance in assessing existing nutritional status and obtaining information about past nutritional history.

The growth, weight and composition of the body depend, in part, on the supply of nutrients and may serve as a useful criterion of one aspect of nutritional status. It should be realized that anthropometric data provide only a description of man's physique. Brozek believed that measurement of body weight in relation to height, properly made and interpreted, is useful in several contexts. This includes evaluation of calorie requirements, assessment of nutriture of a given school child or patient, description of the present nutritional status of different populations and demonstration of improvement of dietary practices.

Brozek (12, p. 148) also stated:

> In the opinion of the committee, anthropometric measurements, including relative body weight, would be of greater practical value in the assessment of nutritional status if properly characterized norms and agreed methods were available for general application.

Brozek believed that the large amount of adipose tissue is located under the skin and the individual's leanness-fatness may be estimated by measuring the thickness of skinfolds.

Davenport (21, p. 265) considered the chief purpose of anthropometry to be:

> 1. The determination of the somatic size differences and proportions in the adult males and females of different races. This is essential to the progress of human genetics.
> 2. The determination of the changes in size and proportions in the body of developing children from egg to adult.

Average anthropometric measurements of any adult population may not remain stable from generation to generation. Environmental conditions and genetic composition are among the many factors which contribute to change.

Estimating desirable body weights of college women should therefore be of value at this point in order to augment the few data gathered. A child, upon thorough examination, would be of specific weight for his height and age. What is this desirable body weight? What is the ratio of the fat to lean or what is the relation of weight to overweight and underweight? Is the table compiled by the Metropolitan Life Insurance Company valid for this certain age? In what body frame group does this child belong? This study attempts to answer these questions. It is hoped that the measurements in this study will contribute to the determination of desirable body weights of college women 18 to 25 years of age and will widen the horizons for further anthropometric research, and perhaps its relation to nutritional status.

CHAPTER II

REVIEW OF LITERATURE

Introduction

The roots of anthropometry reach far back in time. They began with the artists of Old Egypt and Greece who formulated various standards or 'canons' for the purpose of characterizing the measurements of the human body. White, in 1794, basing his assertions upon the observations of both skeletons and living man, made the statement that the forearms of Negroes, in proportion to the upperarms were longer than in Caucasians (68). He showed that there were constant differences in the bodily proportions of the human races. Differences of this sort seem to have been unrecognized before this, even by artists and sculptors. From the time of the Egyptian and Assyrian carvings, they had elaborated and even emphasized the racial characteristics of face and head but had not thought of differences in the other parts of the body. There is the possibility that the classic sculptors of Greece and Rome may have used, indifferently as models, their own people and their foreign slaves.

Then, in 1838 careful measurements not only of the humerus and radius, but of the femur and tibia also were made on 25 skeletons.

The next great advance in this subject of anthropometry was the realization of the fact that many of the bones could be measured practically as well in the living subject as in the skeleton by finding the precise location of their termini by palpitation. Anthropometry continued to develop naturally and was extended to all parts of the body.

Numerous studies have been made in anthropometry but there is still much more information needed. Few studies of anthropometry of living adult women, regardless of race, have appeared in the literature. Hooton (32) states that it is a lamentable fact that comparatively little is known of the terminal phases of the growth cycle - approximately between 21 and 25 years in males and between 18 and 25 years in females. Actually, we do not know when growth stops. Few investigations have been made to study the character of the development ensuing at the end of the growth cycle and the point at which the cessation of this process takes place in women. A shortage of anthropometric data is found among all races.

History of Height-Weight Tables

The earliest data for heights and weights of large groups of the population are from the measurements of the United States Army. More than 500,000 Civil War soldiers were measured in 1863 - 1864. They were largely from old American families and averaged 67.7 inches in height. Another record is for the United States senators of 1866, who averaged 69.5 inches without shoes. The report pointed out they were not typical as they exceeded in height the average of mankind in all parts of the world as well as the average of the United States. The average height of 1,000,000 United States soldiers in 1917-1918 was 67.5 inches. This low over-all average was due to the large number of new Americans, that is, immigrants. About 100,000 Army recruits in 1943 had an average height of 68.1 inches; 85,000 recruits in 1946 averaged 68.4 inches. Smaller special groups of men in the Armed Forces measured in 1946-1953 averaged 68.4 to 70.2 inches. Over the years, average heights have gradually increased (29).

In 1912 the Association of Life Insurance Medical Directors and the Actuarial Society of America compiled data from previous records of heights and weights of civilians who had been accepted for life insurance. Most of the people lived in the cities in the Eastern States and Canada; 216,583 men in 1885-1900 and 221,819 women in 1885-1905. Measurements were made with ordinary indoor clothing and with shoes.

A study of heights and weights was made in 1955 by the United States Department of Agriculture as part of a survey of eating habits in the United States. Data were reported for 6,340 men and 6,680 women. The men 30 to 35 years old in the life insurance study had an average height of 67.6 inches. The men 25 to 29 years old in the 1955 U.S. Department of Agriculture study had an average height of 69.6 inches. Thus men in 1955 averaged at least two inches taller than men 55 to 70 years ago and attained that average five years earlier. Fewer than four per cent of any age group were as tall as six feet in 1955, and three per cent were at least six feet three inches tall. Women averaged about two inches taller in 1955 than 50 years earlier. Women 20 to 29 years old averaged 62.4 inches in 1900-1908 and 64.3 inches in 1955. Only four per cent of the 20-29 year old women in 1900-1908 could be considered tall, 76 inches and over, but 18 per cent of this age group in 1955 were that tall (29).

Older men measured in 1885-1900 were heavier, when compared with the younger men of corresponding height, than those in the 1955 sample. The 1955 weights of the taller men were less at 40-49 years than those for men of the same height in 1885-1900. Women of comparable ages weighed less for their height in 1955 than in 1885-1908. The increase in weight was slightly more from the younger to the older age groups among women studied in 1955 than among those measured in 1885-1908. Men succeed better than women in keeping their earlier weight. Women were four to eight pounds lighter at 25 to 30 years than in 1900, but they gained weight faster in their later years than men did (29).

Freshmen in two men's college were about three inches taller in 1957 than freshmen 75 years before. College men who were six feet and over increased from less than five per cent in the 1880's to about 30 per cent since 1955. Average weights have increased about 20 pounds. Sixty years of consecutive records in two women's colleges show increases in the average heights of freshmen of about two inches. Changes in average weights are much less than those of men - - seven pounds (29).

The new height-weight-age tables show desirable weight for age and are within a range between 15 to 25 pounds below former average weights. The tables are constructed using ranges of weight for each height and type of body build. The body frame is subdivided into large, medium and small. Body frame is determined by chest breadth and hip width (30).

In 1912 life insurance tables, which are still in use, are based on the heights and weights of insured men and women of more than 50 years ago. Adults are advised to maintain in later years the weight recommended for their height at age 25 to 29 years. The Department of Agriculture has developed a table of desirable weights for heights from data on 25 to 29 year old men and 20 to 24 year old women from 100 colleges and universities of the United States in 1948-50. The data represent nude weight-for-height values for the largest segment of the adult population for which recent data is available. The 1955 study shows that persons with education beyond high school generally maintain desirable weight for height better than those with less education (30).

Young women in their twenties average five to six pounds lower than desirable body weight whereas young men show an increase of five pounds in their twenties and thirties. Young women have become more diet and weight conscious than before. Young men are better nourished than previously and tend to reduce their physical activity at an earlier age than formerly (40).

There is a direct relationship between weight gain and age. Both men and women gain weight as they grow older but the pattern is different. Men increase in weight in their twenties and thirties but remain fairly constant thereafter; whereas women increase weight in their thirties and forties (40).

"People have changed in the last 100 years from ignoring obesity to emphasizing the ideal that slenderness is next to godliness" (1, p. 23). Emphasis has shifted from the happy, fat individual to the lean, long-lived one.

Limitations of Traditional Height-Weight Standards

Measurement of the structure of the human body, the classifying of individuals as to the frame type and the prediction of the various factors which have to do with growth and physical fitness, have long been studied as a part of anthropometry. Tables using weight in relation to height and age as an index of health have taken a prominent place in nutritional surveys. According to Roberts (53), Ralph Waldo Emerson was one of the staunchest advocates of the relation of weight to height as a means of determining nutrition. Though he recognized other signs of malnutrition, his faith in the height-weight was sufficient indeed, to allow him to state that the basis of weight for height had proved to be an accurate measure of the condition of under-nourished children and in many thousands of cases observed by him he had never found an instance in which it had proved to be impractical.

The official sanction by Emerson and others has impressed the popular mind with a deep respect for what seemed to be a definite standard of personal health.

For sometime, this rather wholesale grouping of persons has been felt to be inadequate and erroneous. The most serious criticisms of the systematic dependence upon early height-weight-age tables was that no consideration was given to the different kinds of body build; individuals of both heavy and light frames were expected to have the same "normal" weight. Baldwin (3) expressed dissatisfaction with the widespread abuse of the tables for deciding individual normal weight. It was his belief that the chief difficulty is to know what weight is normal for individuals.

Stuart and Meredith (58) emphasized the point that the stockiness or linearity of skeletal build is only one factor in determining body weight. They stated that body weight does not differentiate between the amount of protoplasmic tissue and the amount of fat or water stored in these tissues. It does not distinguish between bone and muscle. It is important to recognize that heavy weight and age may be due in one case to stocky bones, in another to exceedingly well-developed muscles, in a third to large accumulation of subcutaneous fat, and in a fourth to a relatively well-balanced amount of all of these.

Taylor (61) argued that there are wide variations of normal types of build from slender to stocky. He said that in children in good health there is a physical development proportional to the types of build. His argument for using the obviously different types of body build as a more correct basis for proper weight determinations than the generally accepted height-weight tables, brought about new ideas in the field of measurements in relation to health. He classified children as slender, medium, medium heavy and heavy. He prepared weight tables based on height and girth of shoulders, chest, right and left arms, waist, hips, thighs and calves, thus attempting to devise a plan in accord with his idea that tables should take into account the wide variation in type of build.

While height-weight-age tables alone do not characterize an individual's physical or nutritional status they are of value along with other anthropometric measurements in arriving at a more exact definition of an individual, or of the type of a group. Numerous height-weight tables have been produced. In the United States basic height-weight tables were published in 1912 by the Association of Life Insurance Medical Directors and reprinted many times. Brozek (16) stated that the comparisons with fairly recent data obtained on samples of personnel of the Armed Forces justify the conclusion that by and large, the 1912 standards may be used as an approximately valid reference point to which individuals in the United States and populations throughout the world may be compared.

The deviation of body weight from the "standard" for height, sex, and age is a gross indicator of under- or over-development of soft tissues such as adipose tissue, musculature, and viscera. In pathological situations other body components, such as the body fluids accumulated in patients with "hunger edema", can complicate the interpretation of biological significance of deviations from standard so as to make body weight useless even as a very gross indicator of soft-tissue development.

Atheletes performing certain types of physical exercise, notably weight-lifting, develop large muscles. In such cases the muscles will account for a larger fraction of body weight than would be true for the average man. In "normal" adults of a given height the adipose tissue accounts for a large fraction of the individual differences in body weight. However, even in individuals who are neither professional weight-lifters nor are undergoing medical treatment combining high calorie intake with bed rest, (long a fashionable regimen at the tuberculosis sanatoria), the intensity of habitual physical exercise and occupational activity is likely to be reflected in body composition. Brozek (18) matched height and weight for two groups of business and professional men showing no consistent and statistically significant differences in the lateral dimensions of the skeleton, the physically more active men were somewhat heavier, i.e. relatively overweight. At the same time, they were leaner. On the average, the mean skinfold tended to be lower. Characteristically, the chest circumference was larger in the active and smaller in the relatively inactive men. The reverse was true of the abdominal circumference. Statistically, the differences between the two chest circumferences was highly significant.

Body density, used as an indicator of total body fat, was higher in the active and lower in the inactive men, further documenting the trends present in the anthropometric data. The most striking feature was the larger fat-free weight of the physically active men (64 kg. vs. 60 kg. in the inactive group). This was interpreted as indicating that in the active group there was only a minimal "disuse atrophy" of the muscular tissue which appears to be characteristic of the "normal" process of aging, according to Brozek (10).

Similar differences were noted by Keys and Brozek (15) when men differing in the intensity of habitual physical (occupational) work were compared in Minnesota (active switchmen vs. sedentary railroad clerks), in Sweden (shipyard workers vs. white-collar personnel), in Italy (steelworkers vs. firemen), and Japan (farmers plus miners vs. physicians). In each region the men, in the narrow age range from 40 to 49 years, were individually matched in regard to their relative body weight. They were classified on the basis of the distribution of each of the anthropometric characteristics (relative weight, thickness of the upperarm skinfold plus the subscapular skinfold) as Underweight, Average-weight, Overweight, and as Lean, Medium Fat and Fat. With relative body weights matched, in the combined sample the percentages of the active and inactive men in different classes of fatness were as follows: lean 45% vs. 22%; medium fat, 33% vs. 34%; fat 22% vs. 44% respectively. In other words, the active men tend to be lean while sedentary individuals of the same relative weight are more frequently classified as fat. When attention was focused on men who fell into the upper third of the distribution of either variable, among the "active" men there was a relative predominance of men who are heavy but not fat while the more "sedentary" individuals were frequently classified as fat without being heavy.

When consideration is given to individuals in the total range of leanness-fatness, from emaciation to extreme degrees of obesity, one may expect a sizable correlation between any two criteria of fatness. There is no problem in recognizing the extreme degrees of obesity or emaciation, whether inspection, relative weight or skinfolds are used.

The problem of evaluating relative fatness becomes real, precisely in those individuals who deviate only in moderate degrees from the standard weight for age, sex and height. Three points need to be kept in mind in this connection: one, these individuals represent the majority of the population; two, it is in this range that the relative weight is least reliable as a criterion of leanness-fatness and its discriminatory power must either be sharpened by taking into account lateral dimensions of the skeleton or it must be supplemented by more direct measures of fatness; three, the dependability of the traditional relative weight decreases as the heterogeneity of the population, genetic and occupational, increases.

Body Composition in Vivo

According to Wohl and Goodhart (71) the development of methods for estimation of the gross composition of the human body in vivo has provided an important tool for metabolic analysis and the evaluation of nutritional status.

The study of body composition now appears to offer an important approach to nutritional correction and control of body weight. As our knowledge of body composition increases, it may help us find solutions to such problems as how to produce and maintain persons of high mental and physical fitness and how to strengthen our medical and surgical therapeutics for sick people (56).

Methods for the analysis of body composition are potentially useful tools, not goals in themselves. They enable us to examine the human body in terms of new dimensions (9).

Concern with the genesis and the significance of individual differences reflected by body composition was present from the outset. Matiegka's early endeavors were the result of his quest for a comprehensive quantitative characterization of man's nutritional status (8), (42).

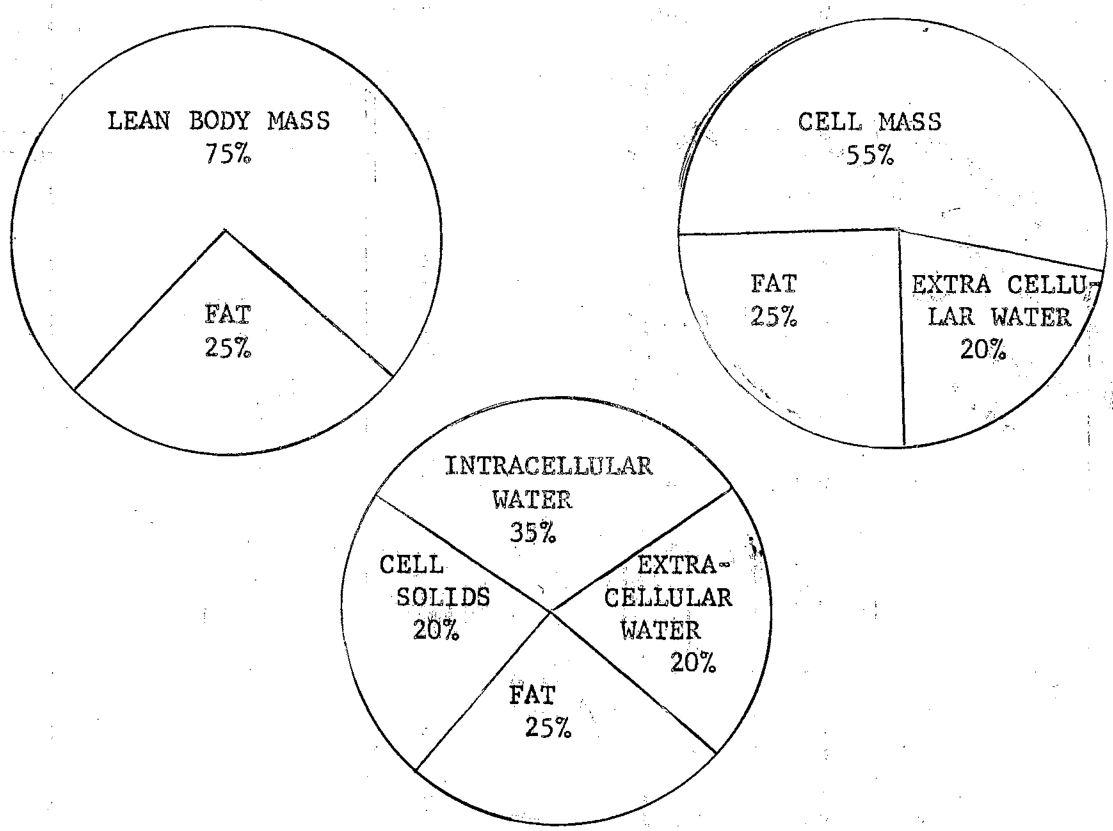
Densitometric analysis of body composition was applied some thirty-five years ago by Kohlrausch (37) to study the effects of exercise on the body. Behnke's (5) interest in body composition developed in the context of applied physiology with special reference to deep sea diving. One of the early studies was devoted to the body composition of athe-letes (5). It has involved measurement of the amount of gaseous nitrogen eliminated by the organism under specific conditions such as are encountered, for example, in deep-sea diving where controlled decompression must be carried out after the dive. Around 1940 Moore and his colleagues (44) became interested in body composition in conjunction with treatment of patients who had been badly burned. At the Laboratory of Physiological Hygiene, University of Minnesota, body composition changes caused by prolonged semistarvation and subsequent rehabilitation were studied by a variety of techniques (13), (36).

Brock and Hanpen stressed that underfeeding, overfeeding and unbalanced feeding affects the external morphology as well as the relative size of various tissues and fluid compartments of the body (7).

Techniques for analysis of body composition, especially the somatometric approach, are directly relevant for human nutrition. Application of these techniques has been broad and exceeds the compass of traditional research (26).

Very few direct analyses of human bodies, or even parts of the bodies, have been recorded. Widdowson (67) et al analyzed the major components of the body. Although the analyses are of great value, these investigations point out that the data must be interpreted with caution before reliable figures can be established.

In their studies of the chemical composition, they emphasized the importance of quantitative evaluation of body weight with specific reference to fat, fat-free tissue mass, water and minerals. Behnke's (5, p. 198) procedures were developed for partitioning the body weight of living adults into its major components as shown below.



Estimated Body Composition in Vivo of Boys

During World War II intensive research on body composition was stimulated and new methods were developed for in vivo analysis of the human body.

Macy and Kelly (41) stated that for the purpose of calculating the distribution of the body weight of children into its component parts - total body water, extracellular water, intracellular water, lean body mass, and fat, it is possible thus to predict to reasonable accuracy body composition in childhood in relation to physical and chemical growth and maturation. Some of the tests previously described were anthropometric measurements, roentgenographic assessments, X-ray, densitometry and hydrometry and helium dilution process.

Again Behnke (5) stated that lean body mass, as used in several of his studies, included no fat. In this term a certain amount of "essential" fat is assumed. Therefore, when Behnke's equation was applied, his values were adjusted to eliminate the 10% essential fat for boys and 15% for girls that he included in lean body mass. This is based on the concept that there is what Behnke (5) calls the lean body mass (LBM) or what Keys and associates (35) prefer to designate the fat-free body, the composition and specific gravity of which are quite constant. In the thin individual this LBM may have little or no fat added to it. In other persons the varying amounts of fat added to it represent varying degrees of fatness. Since the specific gravity of body fat is much lower than that of the LBM, the specific gravity of the body as a whole should vary inversely with the degree of fatness, and of course directly with the degree of leanness.

Macy and Kelly (41) included this "essential" fat in total body fat, which makes their values for total fat appear higher than those reported by Behnke (5).

Widdowson, McCance and Spray (67) developed a simplified method of obtaining body composition which is applicable to living persons. According to their thesis, the body is, in large measure composed of total body water, extracellular water, cell mass, fat and minerals. They determined body water by the dilution procedure.

Brozek and Keys (17, p. 141) offered a table giving representative values of specific gravity and body fat content for various ratings of endomorphy and ectomorphy. These authors point out, however, that this approach to the question of body fat content, or expression of nutritional status

> ... appears to be a devious and inefficient route, except under special conditions in which direct measurements on the living man were not or could not be made... It is the estimation of the absolute and relative amount of fat - - which accounts for the largest part of the differences among adult individuals - - of muscles, and of bones, which is the principal concern of nutritionally oriented anthropometry.

Basic data on the body composition of women sixteen to thirty years of age were presented by Young et al (63). Figures included are for body density, total body water, creatinine excretion, basal oxygen consumption, skinfold thickness at 12 sites on the body, fat pad measurements on soft tissues, X-ray, and some 21 anthropometric measurements, both skeletal and envelope or circumference. Mean body density decreased and hence body fatness increased by decade, after the fortieth year. The changes represent an increase in body fatness of 23.1 per cent in the fifth decade, 46.0 per cent in the sixth, and 55.3 per cent in the seventh in comparison with the third decade. Subcutaneous fat, as measured by skinfold thicknesses or fat pad measurements on soft tissue X-ray examination, reflected changes in total body fatness through the fifth decade fairly accurate but not thereafter. There appears to be increasing central or non-subcutaneous fat deposition in the women in the sixth and seventh decade.

Development of Anthropometric Measurements

In Human Biology (51), the Committee on Nutritional Anthropometry of the Food and Nutrition Board of the National Research Council set forth recommendations concerning bodily measurements. Recommendations were made for the selection of measurements which would define the skeletal framework and the status of subcutaneous fat-body weight reported as in the nude, stature, bi-iliac and biacromial diameter, limb circumference and measure of adipose tissues.

Stuart and Meredith (58) stated that the attributes which ordinarily should be recorded by measurements are over-all body size in length and mass of the relative amounts of the three principal body tissues which determine total mass-stockiness of the bony skeleton, bulkiness of the musculature and quantity of skin and subcutaneous tissue. The measurements to be taken in this study afford such an opportunity.

Krogman (38) pointed out certain extraneous factors which affect the accuracy of both height and weight measurements. They are, a) time of the day; b) before and after exercise, meal or elimination; c) socio-economic status of a person, especially with reference to diet;

d) family-hereditary background including ethnic stock and body build factors; e) seasonal and climatic factors.

Tanner (59) has pointed out that anthropometric measurements describe the individual and give an analytic expression to individual differences.

Studies on Skinfold Measurements

Jackson (33) measured 1022 women entering the University of Minnesota during the school year of 1925-26 whose average age was 19.6 years. Their stature averaged 161.7 cm. and their weight 54.37 kg. or 119.9 lbs. He found that a correlation of stature with age was insignificant in the Minnesota women. Correlation between body weight and age was low as there was only a slight tendency for increase with age.

Then Steggard (57) and associates claimed a mean stature of 162 cm. and weight of 122 lbs. when measuring Smith College age students. The results were the same as with Jackson's previous study.

Young (64) studied the body composition of 94 young college women ranging in age from 17.2 to 27.2 years. The mean age was 20.36 $\pm$ 1.951 years. The mean height was 65.94 $\pm$ 2.374 in. The mean weight was 58.96 $\pm$ 6.445 kg. ranging from 44.11 to 76.20 kg. Both the mean and height of her study are greater than the former studies. Young reported a biacromial width of 37.24 cm. and bi-iliac width of 28.50 cm.

Todd and Lindala (62) when studying the dimensions of the body reported that in standing height for both female and male a low average was found as compared with standard height-weight tables.

Herskovits (31) in a study he made on anthropometric measurements pointed out that race has some influence on the relationship of hip width and stature.

Donelson et al (22) made an extensive study on various anthropometric measurements on 1013 college women in the middle states. It was pointed out that although the states represented in this study are in the same general geographical location, there are differences found in the measurements recorded in different states. She made comparisons of previous studies on these college-age women from the different states where earlier studies are also available, plus her study. She found that the college freshmen of her study were taller and heavier at ages 17, 18, 19, and 20 than those entering at earlier dates.

Ohlson (47) et al made extensive research when she subjected 1013 college women to several anthropometric measurements and found them to be inconsistent.

Studies showing skinfold measurements of college women are almost non-existent. Young (64) and Skerlj et al (55) reported skinfold measurements of college women. Young measured 94 Cornell University subjects, whose mean age was 20.36. The thickest pads were found on the lower trunk, especially in the abdomen, midline halfway between the umbilicus and pubis (33.04 ± 10.43 mm.). The other major fat deposits measured were the upper legs and upper arms; thighs 32.00 ± 7.98 mm.; triceps, 25.43 ± 6.83 mm. Measurements made on Minnesota women by Brozek et al (10) were slightly higher in some of these locations. It should be noted, however, that Young used calipers having a pressure of 10 gm/mm while Brozek used those with a pressure of 5 gm/mm. This may account for the difference in measurements.

While skinfold measurements are limited, it is felt that more and more measurements will be made thus according to Garn (27). Skinfold measurements point out marked interpersonal difference not only on the amount of fat but also in the way fat is distributed and provides a valuable measure of fatness.

All these results obtained were quite conflicting. The limited data on anthropometry of college-age women makes it hard to draw some valid conclusions.

Basis of Skinfold Measurements

Several studies which deal with the deposition of fat help one comprehend "normal" body weight and the significance of weight changes. Measurement of the subcutaneous fat has been a part of anthropometric studies for many years. It is not how heavy a person is or how heavy he becomes that is important in determining whether a person is overweight or underweight. Rather, it is how much fat he carries and how much fat he adds, according to Garn (27) in one of his studies.

According to Brozek (16), Richer noted that variations in the thickness of the skin proper are very small and that for practical purposes, the skin can be considered constant. Richer pointed out that there is no adipose tissue on some parts of the body - i.e. the nose and the eyelids. It is very thin on the back of the hand and dorsum of the foot. It is the thickest but irregularly distributed on the trunk.

As much as half or more of the total fat is contained in the subcutaneous tissue which can be characterized quantitatively by measuring the thickness of the skinfolds by calipers or by noting the layer of skin plus subcutaneous tissues in soft-tissue roentgenogram which Reynolds (52) cited in one of his studies.

Orpin and Scott (48) studied the usefulness of a technique for converting skinfold measurements into a direct expression of total body fat. They pointed out that a fold of skin lifted between the thumb and forefingers comprises two layers of "true skin" and a double layer of subcutaneous fat. Subtraction of "true skin" thickness leaves a value which is a measure of double subcutaneous fat layer.

Cowgill (20) stated that the assessment of fat in the living body might also be estimated from the amount on nontoxic, fat soluble substance that is readily absorbed by body fat. He said further that physical measurements of the body height, weight, circumference of the chest, et cetera - are the first parameters that come to mind in this connection. Of considerable interest, too is the relation of these measurements to thickness of the skinfolds, because one of the important places where fat is stored is in the subcutaneous tissue.

Seltzer (54) explored various skinfold thickness and anthropometric measurements and tested whether these can be predictors of obesity based on actual body fat content. From their measurements, it was suggested that skinfolds were the best predictors of the percentage of total body fat.

Matiegka (42), a Czeck anthopologist, developed a formula for estimating the total quantity of the skin plus subcutaneous tissue. The weight of skin, plus subcutaneous tissue is about 17% of the body weight in the adult male. Of this, skin alone accounts for six per cent and subcutaneous tissue for 11 per cent. The skin weight to total weight in women is the same as in men. However, subcutaneous tissue represents about 24 per cent of the body weight of men, according to Wilmer (69).

Newman (46) in his study of 10-day subsistance on the so-called "survival rations" measured skinfolds on the abdomen, chest and arm. He checked the changes in body fat as reflected by the alterations in the thickness of skinfolds by means of an equation derived by Brozek (14). Newman (45) commented on the relatively simple technique that this involved and felt that the ease with which the data were collected made the method useful for studying larger groups where the determination of specific gravity is obviously impossible. A formula for estimating specific gravity from the data on height and weight such as Cowgill (20) has developed could proved useful in situations like this.

Sites of Skinfold Measurements

Brozek (14) and Edwards (24) stated that the selection of sites involved several considerations, such as accessibility, precision in locating the sites, relative homogeneity of the layer of skin and subcutaneous fat in a given region, and validity. These measurements serve as an index of total fat. Edwards further stated in his study on the distribution of subcutaneous fat, 53 selected sites are representative of most of the body, giving good sites or locations. Then, in another study he made, he found the patterns of distribution of subcutaneous fat to be closely related in both sexes, at all ages, and at varying degrees of obesity. The only chief difference was the total amount of subcutaneous fat. It was noticed that in a normal female the average skinfold was approximately 55 per cent greater than in normal males. For women 20 to 24 years of age, 64 inches tall and weighing 121 pounds, the average skinfolds were 640 millimeters. For men, 20 - 24 years of age, 67.8 in. tall and weighing 146.1 pounds have a corresponding value of 412 millimeters. The change in total subcutaneous fat with sex generally took place after puberty, the chief being that women have about 1.25 times as much fat on their legs as men.

The site along the mid-axillary line, at the xiphoid process appears especially advantageous. Others such as the supra-iliac skinfold and the thorax skinfold are also of some advantage according to Pascale et al (49).

The subscapular skinfold is also readily measured and has the advantage that the layer of skin plus subcutaneous tissue is fairly uniform in this region, as stated by Brozek (16), and Pett and Olgwie (50).

Several authors pointed out racial differences in the amount of subcutaneous fat; i.e. Newman (45), Lee and Lasker (39), Ohlson (47), and Wolff and Steggard (70).

Newman (45) used only three measures of fat as an indication of total subcutaneous fat - the subscapular, supra-iliac and upper arm skinfolds. He felt this to be as reliable as the coefficients of correlation between the sum of measurements of 53 sites mentioned by Edwards (24) earlier and the sum at the three sites he used showed very close agreement, 0.99. As a rule, the actual values of the skinfolds alone are used as a measure of fatness.

For many research purposes, as well as practical application, complete accuracy is not essential and also it is not essential to know the total amount of fat in the body. It is enough to know the differences, in subcutaneous fat between two bodies or the differences in the same person at different levels of nutrition.

Standard Tools and Procedures

In order to get valid results in this study, it was necessary to standardize the pressure with which the calipers were applied. At the same time consideration was given to the points on the body surface where caliper readings were taken. The need for constant pressure calipers has been recognized for sometime now. Several skinfold calipers have been developed.

A systematic study of the various factors affecting the design of skinfold calipers and the accuracy of the skinfold measurements was reported by Edwards (24). The readings were made with an accuracy of 0.1 millimeters, are corrected for the thickness of the two compressed layers of skin and transformed into logarithmic equivalents in order to remove or at least minimize skewness of the distributions of skinfold thickness (16).

The Lange Caliper developed by K. O. Lange is simple and provides accuracy in measurement of subcutaneous tissue.

It is important to use calipers in which the pressure is constant from reading to reading and over the range of skinfold thicknesses studied. In earlier models of calipers the spring tension was very low at small openings, but increased rapidly as the jaws of the calipers are opened.

Several other features must be standardized in order to assure comparabilities of skinfold measurements made by investigators. The skin should be lifted by grasping firmly the fold between the thumb and the forefinger. The width of the skin that is enclosed between the fingers is also an important factor. It cannot be standardized, in its absolute size, for all sites of the body. For a given site the width of the skin should be minimal still yielding a well-defined fold. The depth of the skin fold at which the calipers are placed on the fold is another important factor. The two sides of the fold are not likely to be strictly parallel from the top to the bottom of the fold especially when the skin is lifted by one hand, the fold being narrower near the crest and larger toward the base. Here again, the correct distance at which the calipers should be placed is defined as the minimal distance from the crest at which a true fold is obtained upon application of the calipers to the skin, according to Brozek and Keys (15).

Data obtained with skinfold calipers have been found to agree with measurements from roentgenograms of soft tissues, according to a study done by Baker (2) et al. In turn these determinations of subcutaneous fat have been correlated with calculations of total body fat obtained by other methods of Brozek (14).

CHAPTER III

METHOD AND PROCEDURE

Selection of Subjects

Ninety-five healthy, female college students ranging in age from 18 to 25 years inclusive were chosen as subjects in the study. At the time of the experiment they were free from disease as determined by the university physical examinations upon entrance.

The subjects were all members of a class titled Introduction to Nutrition in which they were keeping a weekly record of body weight for one semester, or approximately 16 weeks of time. Their body weight was evaluated in terms of Height-Weight-Age Tables of the Metropolitan Life Insurance Company which used small, medium and large body frame categories. Many of these subjects did not know which body build they really were and so were insecure in whether they were within the range of desirable weight for height and age.

Instruments and Equipment

A room was set up specifically for use in taking these anthropometric measurements. The equipment used was as follows:

1. Scales: Fairbank balance scales were used. The scales have a capacity of 300 pounds and weight can be taken to the nearest

tenth of a pound.

2. Sliding wooden caliper: It consisted of a wooden rod 70.5 centimeters long; 1.6 centimeters broad; and 1.6 centimeters thick. It had two wooden arms - one stationary and the other movable (43).

3. Six foot ruler: The ruler was made especially for this purpose and was graduated in tenths of an inch for ease in calculations. It was fastened flat against the wall (43).

4. Wooden Triangle: A triangle of wood was used with the steel tape in determining the distance from the floor to the crown of the head.

5. Steel tape: A 1.5 millimeter standard, flexible tape, graduated in centimeters and inches, was used (43).

6. Lange skinfold caliper (10): This caliper was especially designed for simple, accurate measurement of subcutaneous fat. It was used at the personal suggestion of Dr. Josef Brozek, a noted authority in this field. The caliper has pivoted tips which adjust automatically for parallel measurement of skinfolds. The spring-loaded levers provide a substantially constant pressure of 10 gm/mm over the entire operating range. See appendix p. 69

7. Chair: A chair was available for those measurements which were taken with the subject seated.

8. Stool: The investigator found it easier to read some of the measurements accurately while seated on a stool rather than standing.

Anthropometric and Skinfold Measurements

The anthropometric measurements to be used in this study, except specific skinfold measurements, were recommended by the Committee on Nutritional Anthropometry of the Food and Nutrition Board of the National Research Council.

All measurements were taken in May, 1966. Since several authors have indicated that body weight is less in the afternoon than upon rising all anthropometric measurements were taken from 12 noon to 6:00 p.m. All measurements were taken three times in succession on the right side of the body with the subject wearing a gown designed for measuring subcutaneous tissue (25). See appendix p. 70. An average of three readings was used for calculations. Measurements, except height and weight were recorded in cm. and mm. A form for recording anthropometric measurements was designed and is included here. See appendix p. 71. The order of procedure and technique involved in taking these measurements are:

1. Weight - the subject was requested to stand in the center of the platform scales. Readings were made to the nearest one-tenth of a pound and were recorded. The readings were later converted to kilograms.
2. Height - this measurement was taken as the distance from the floor to the highest point of the top of the head. It was taken against a wall so as to increase standardization of posture. The subject was required to stand on a flat surface with her bare feet parallel; heels, buttocks and shoulders touching the wall and hands at her side. The head was held comfortably erect. A wooden ruler was placed flat on the head so that the skull is felt, but not enough to make the subject shrink. The measurement was taken to the nearest one-tenth of an

inch and was later converted to cm. (4),(43).

3. Biacromial diameter (or shoulder breadth) - this is the distance between the most lateral margins of the acromion process of the scapula. The subject was asked to stand relaxed but erect with her back to the examiner. The stationary end of the caliper was placed just to the left of the acromial process, and the free end moved until it was just to the right of the acromial process. The caliper was held so that the ends pointed upward and forward at an angle of approximately 45 degrees. The measurement was taken without pressure and the readings recorded to the nearest one-tenth of a centimeter (10).

4. Maximum circumference of the upper arm - this measurement was taken with the arm hanging relaxed at the side of the subject. A flexible steel tape was placed at the right angles to the long axis of the arm across the largest part. The tape was applied lightly to the skin and the readings recorded to the nearest one-tenth cm. (12).

5. Bi-iliac diameter or pelvic breadth - the bi-iliac diameter can be obtained as the greatest distance between the lateral margins of the iliac crests. The subject stands erect. Measuring from the front, the examiner presses the arms of the caliper firmly against the widest flare of the iliac crest. The arms of the calipers are tilted slightly upward. Readings are reported to the nearest one-tenth cm.

6. Maximum circumference of the thigh - the subject was required to stand with feet several inches apart while the measurement was taken perpendicular to the long axis of the thigh, with the tape in the gluteal fold. Readings were recorded to the nearest one-tenth cm. (4).

7. Maximum circumference of the calf - the subject is required to stand with feet several inches apart and with her weight equally distributed through both lower limbs. The maximum girth of the calf is measured at right angles to its axis; the contact of the tape is definite but slight. Readings are recorded to the nearest one-tenth of a cm.

In order to satisfy the skinfold measurements, specific sites were chosen as determined by Brozek (10). Criteria for choosing these sites were:

1. Representation of regions to show large variations in subcutaneous fat (abdomen and chest).
2. Representation of the extremities (arm and thigh measurements).
3. Ease of locations.

Skinfold Thicknesses

The general objective was to measure the thickness of a complete double layer of skin and subcutaneous tissue without including any of the underlying muscle tissue. The examiner placed the thumb and index finger of the left hand over the region of measurement in such manner that: a) the two digits were in an opposable relationship, b) distance between the two digits approximately thirty to forty millimeters, c) the interdigit plane is at right angles to the long axis of the body, or hanging extremity of the subject[1]. The two

[1]The abdominal measurement differs from that of the others in that branches of the calipers are placed horizontally rather than vertically.

digits are then moved directly toward each other so that a complete double layer of skin and subcutaneous tissue is grasped firmly between them. This fold is held with moderate firmness while the instrument is applied to the fold with the right hand. Measurements are recorded to the nearest one-tenth centimeter.

1. Upperarm skinfold - the skinfold was made at the upper arm (over the triceps), at the level midway between the tip of the acromial process of the scapula and at the tip of the elbow.

2. Subscapular skinfold - this measurement was taken at the region below and slightly to the inferior angle of the right scapula and in the transverse plane of the xiphoid cartilage.

3. Abdomen skinfold - measurement was taken at the front of the abdomen, approximately 2 cm. above the umbilicus.

4. Thigh skinfold - measurement was taken halfway down the thigh, over the rectus femorus muscle.

5. Chest skinfold - this measurement was taken somewhat higher in women than in men. This is taken at the axillary border of the pectoralis major muscle.

6. Supra-iliac skinfold - caliper was applied approximately 2 centimeters superior to the crest of the ilium in a line vertical with the axilla.

7. Waist - this measurement was taken between the ribs and the iliac crest.

Statistical Analysis

Previous studies in this area indicated many ways of presenting the data that might be applied to the present study.

Brozek (10) stated that in any anthropometric data the first step should be the presentation of the raw data. This is best accomplished through the frequency distribution, which shows an arrangement of the items of a series of classes and indicates the number of data occurring within each group.

For completeness, means, standard deviation, correlation coefficients and coefficients of variation in per cent were also obtained in this study.

One of the aims of this study was to estimate the total fatness or leanness from a more easily accessible measure in the body.

The prediction equations used in this study are of the form,

$$\hat{Y} = \beta_0 + \beta_1 X + \xi$$

where Y = observed weight

X = observed age

β_0 = intercept

β_1 = slope of regression

ξ = random error associated with Y

The estimate, Y, is then found by the least square method procedure to be,

$$\hat{Y} = \hat{\beta}_0 + \hat{\beta}_1 X$$

A more general linear equation may be raised by combining several prediction variables,

$$\hat{Y} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots \beta_{14} X_{14}$$

where β's are partial regression coefficient

and the X's are the predictive variables desired in this linear model. In this study the X's are the anthropometric and skinfold measurements taken respectively on fourteen sites of the body.

CHAPTER IV

RESULTS AND DISCUSSION

Characteristics of Data Collected

Frequency Distribution, Arithmetic Mean, Standard Deviation, Correlation Coefficient, Coefficient of Variation in per cent

There were far too many readings to use in all statistical analyses. The analyses were made on measurements from 95 college women. An IBM 7040 electronic computer was used to summarize the data for this study and to perform statistical analyses.

The mean age of the subjects participating in this study was 19.06, ranging from 18 to 25 years. The mean height was 162.25 centimeters and the mean weight 55.56 kilograms. Table 1 depicts the frequency distribution of each of the anthropometric and skinfold measurements. The norms were derived from a frequency distribution of the single criteria of fatness. When the distributions are normal; in the statistical sense, the norms can be based effectively on the mean and standard deviation of the values of the sample. It can readily be seen that the greatest accumulation of each of the measurements lies around the mean of the sample.

Coefficient of variation in per cent are presented in Table 2 along with the mean and standard deviation.

It may be observed that the coefficient of variations ranged from

Table 1 Distribution of average anthropometric measurements exclusive of specific skinfold measurements of 95 college women.

Ht. - in. Interval	f[1]	Ht. - cm. Interval	f[1]	Wt. - lbs. Interval	f[1]	Wt. - kg. Interval	f[1]
56.0-57.5	1	141.0-144.7	3	96.0-102.4	4	43.0-46.0	4
57.5-59.0	0	144.7-148.4	6	102.4-108.8	5	46.0-49.0	7
59.0-60.5	4	148.4-152.1	9	108.8-115.2	17	49.0-52.0	9
60.5-62.0	5	152.1-155.8	16	115.2-121.6	18	52.0-55.0	19
62.0-63.5	25	155.8-159.5	19	121.6-128.0	12	55.0-58.0	16
63.5-65.0	20	159.5-163.2	16	128.0-134.4	13	58.0-61.0	16
65.0-66.5	20	163.2-166.9	13	134.4-140.8	19	61.0-64.0	13
66.5-68.0	17	166.9-170.6	5	140.8-147.2	7	64.0-67.0	5
68.0-69.5	2	170.6-174.3	4	147.2-153.6	3	67.0-70.0	3
69.5-71.0	0	174.3-178.0	4	153.6-160.0	1	70.0-73.0	3
71.0-72.5	1			160.0-166.4	0		

Biac. diam. (cm.) Interval	f[1]	Bi-iliac diam. (cm.) Interval	f[1]
33.0 - 34.7	1	26.0 - 27.3	2
34.7 - 36.4	3	27.3 - 28.6	1
36.4 - 38.1	20	28.6 - 29.9	8
38.1 - 39.8	34	29.9 - 31.2	19
39.8 - 41.5	29	31.2 - 32.5	23
41.5 - 43.2	6	32.5 - 33.8	24
43.2 - 44.9	1	33.8 - 35.1	9
44.9 - 46.6	1	35.1 - 36.4	6
46.6 - 48.3	0	36.4 - 37.7	1
48.3 - 50.0	0	37.7 - 39.0	1
50.0 - 51.7	0	39.0 - 41.0	1

[1] frequency

Table 1 (Continued)

Upper arm circum. (cm.)	f[1]	Thigh circum. (cm.)	f[1]
Interval		Interval	
20.0 - 22.0	0	44.8 - 46.9	1
22.0 - 24.0	1	46.9 - 49.0	5
24.0 - 26.0	3	49.0 - 51.1	4
26.0 - 28.0	14	51.1 - 53.2	6
28.0 - 30.0	17	53.2 - 55.3	10
30.0 - 32.0	38	55.3 - 57.4	15
34.0 - 36.0	20	57.4 - 59.5	19
36.0 - 38.0	1	59.5 - 61.6	15
38.0 - 40.0	0	61.6 - 63.7	5
		63.7 - 65.8	5
		65.8 - 67.7	1

Calf circum. (cm.)	f[1]	Ave. skinfold thickness (mm.)	f[1]
Interval		Interval	
26.0 - 27.4	0	8.0 - 9.7	1
27.4 - 28.8	2	9.7 - 11.4	1
28.8 - 30.2	3	11.4 - 13.1	2
30.2 - 31.6	4	13.1 - 14.8	6
31.6 - 33.0	15	14.8 - 16.5	9
33.0 - 34.4	17	16.5 - 18.2	24
34.4 - 35.8	18	18.2 - 19.9	18
35.8 - 37.2	21	19.9 - 21.6	17
37.2 - 38.6	9	21.6 - 23.3	17
38.6 - 40.0	6	23.3 - 25.0	0

[1] frequency

Table 1 (Continued)

Upper arm skinfold (mm.)	f[1]	Subscapular (mm.)	f[1]
Interval		Interval	
6.0 - 8.5	4	5.0 - 7.5	3
8.5 - 11.0	4	7.5 - 10.0	11
11.0 - 13.5	12	10.0 - 12.5	20
13.5 - 16.0	20	12.5 - 15.0	19
16.0 - 18.5	15	15.0 - 17.5	14
18.5 - 21.0	5	17.5 - 20.0	10
21.0 - 23.5	21	20.0 - 22.5	6
23.5 - 26.0	3	22.5 - 25.0	4
26.0 - 28.5	3	25.0 - 27.5	5
28.5 - 31.0	5	27.5 - 30.0	1
		30.0 - 32.5	2

Supra-iliac (mm.)	f[1]	Abdomen (mm.)	f[1]
Interval		Interval	
4.0 - 6.8	8	6.0 - 7.9	4
6.8 - 9.6	19	7.9 - 9.8	20
9.6 - 12.4	4	9.8 - 11.7	6
12.4 - 15.2	15	11.7 - 13.6	19
15.2 - 18.0	16	13.6 - 15.5	16
18.0 - 20.8	11	15.5 - 17.4	10
20.8 - 23.6	6	17.4 - 19.3	8
23.6 - 26.4	4	19.3 - 21.2	11
26.4 - 29.2	10	21.2 - 23.1	0
29.2 - 32.0	2	23.1 - 25.0	1

[1] frequency

Table 1 (Continued)

Chest (mm.)	f[1]	Waist (mm.)	f[1]
Interval		Interval	
3.0 - 4.7	5	4.0 - 5.7	17
4.7 - 6.4	3	5.7 - 7.4	9
6.4 - 8.1	4	7.4 - 9.1	11
8.1 - 9.8	9	9.1 - 10.8	11
9.8 - 11.5	28	10.8 - 12.5	13
11.5 - 13.2	10	12.5 - 14.2	12
13.2 - 14.9	31	14.2 - 15.9	7
14.9 - 16.6	2	15.9 - 17.6	9
16.6 - 18.3	1	17.6 - 19.3	2
18.3 - 20.0	2	19.3 - 21.0	4

Thigh (mm.)	f[1]	Total skinfold thickness (mm.)	f[1]
Interval		Interval	
17.0 - 19.2	7		
19.2 - 21.4	14	86.0 - 101.8	5
21.4 - 23.6	8	101.8 - 117.6	14
23.6 - 25.8	15	117.6 - 133.4	17
25.8 - 28.0	13	133.4 - 149.2	23
28.0 - 30.2	17	149.2 - 165.0	16
30.2 - 32.4	8	165.0 - 180.0	8
32.4 - 34.6	7	180.0 - 196.6	5
34.6 - 36.8	1	196.6 - 212.4	3
36.8 - 39.0	3	212.4 - 228.2	2
39.0 - 41.2	2	228.2 - 244.0	2

[1] frequency

Table 2 Presentation of anthropometric measurements of 95 female college women
Mean Age = 19.06 years, S. D. 1.02

Measurement	Unit	Mean	Standard Deviation	Coefficient Variation in Percent
Height	cm.	162.25	6.29	3.88
Weight	kg.	55.56	5.93	10.67
Biacromial Diameter	cm.	32.05	2.88	8.98
Upper Arm Circum.	cm.	24.92	2.50	10.03
Bi-iliac Diameter	cm.	26.52	2.07	7.80
Thigh Circum.	cm.	47.80	3.68	7.69
Calf Circum.	cm.	34.36	2.46	7.16
Average Skinfold Thickness	mm.	14.15	3.48	2.45
Upper Arm	mm.	10.64	2.53	23.77
Subscapular	mm.	8.77	2.01	22.92
Abdomen	mm.	17.43	4.92	11.92
Waist	mm.	11.43	3.99	34.94
Chest	mm.	13.62	5.11	37.52
Thigh	mm.	9.14	2.10	22.96
Total Skinfold	mm.	23.11	3.97	17.18

37.52 for the supra-iliac to 2.45 for the average skinfold thickness. The average skinfold is the least variable measurement. The next lowest is height for which the coefficient of variation is 3.88 per cent. Weight in kilograms, shows a coefficient variation of 10.67. The skinfold measurements showed the greatest variability.

Tables 3 and 4 were made to show the relationship between height and various anthropometric measurements. The tables present the average anthropometric measurements of the subjects summarized by height. Observing these tables and also Figure 1, the relationship of weight to height irrespective of age, shows no definite trend.

Many studies present the idea that a person of a given height and age should have a corresponding weight. While an increase in weight is usually the result of "fattening", the relationship does not hold in every case. An individual may be overweight, but the increase in weight may be due to changes in body components (bones, muscles, fluids) other than fat. An athlete may be overweight as a result of muscular development rather than fat deposition; an edematous person may be overweight simply because of fluid accumulation.

There was also no definite increase in mean height and weight with age. Subjects at eighteen years of age weighed 121.8 pounds and had a height of 64.1 inches. At nineteen they weighed 119.08 pounds and were 63.1 inches tall. At twenty the subjects were 66 inches tall and weighed 128.7 pounds.

Interrelationship of Anthropometric Measurements with Other Variables

Correlation coefficients on measures of height, upper arm circum-

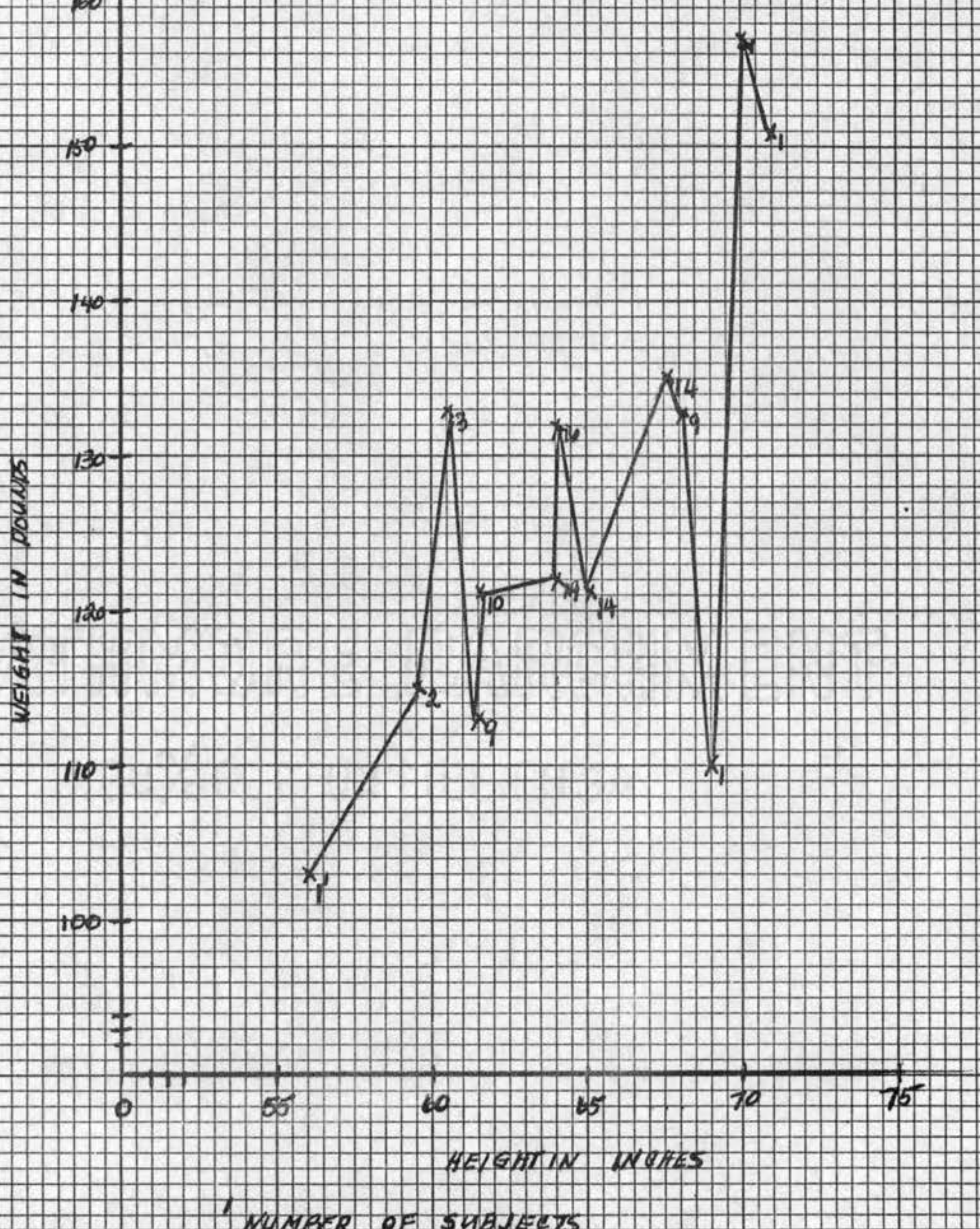


FIGURE 1. RELATIONSHIP OF HEIGHT TO MEAN WEIGHT OF 95 COLLEGE WOMEN.

Table 3 Average anthropometric measurements of 95 college women

No. of subj.	Height cm.	Height in.	Weight kg.	Weight lbs.	Age yrs.	Upper arm circum. cm.	Calf circum. cm.	Thigh circum. cm.	Bi iliac diam. cm.	Biacromial diam. cm.	Average skinfold thickness mm.
1	140.0 142.5	56- 57	46.40	102.2	19.0	21.17	28.68	49.17	30.21	49.60	12.34
2	147.5 150.0	59- 60	52.40	115.5	18.33	24.52	34.42	55.90	31.46	38.23	12.63
3	150.0 152.5	60- 61	59.32	131.1	20.0	21.03	34.22	57.16	32.13	37.64	13.23
9	152.5 155.0	61- 62	51.67	113.8	18.1	25.61	34.81	53.62	32.98	36.20	10.23
10	155.0 157.5	62- 63	55.17	121.5	18.2	24.52	38.40	53.38	31.07	38.79	17.29
14	157.5 160.0	63- 64	55.54	122.0	18.4	24.20	34.90	49.60	32.08	38.95	11.75
16	160.0 162.5	64.0- 65	59.66	131.4	18.4	26.80	35.40	58.85	29.03	40.18	13.34
14	162.5 165.0	65.0- 66	58.51	121.1	18.6	34.83	45.28	67.20	32.60	33.48	16.07
14	165.0 167.5	66.0- 67	60.85	135.0	18.7	24.15	35.18	60.07	32.20	37.66	13.69

Table 3 (Continued)

No. of subj.	Height cm.	Height in.	Weight kg.	Weight lgs.	Age yrs.	Upper arm circum. cm.	Calf circum. cm.	Thigh circum. cm.	Bi iliac diam. cm.	Biacromial diam. cm.	Average skinfold thickness mm.
	167.5	67-		132.3							
9	170.0	68	60.08		18.1	26.70	30.70	57.73	31.36	38.33	14.11
	170.0	68		110.7							
1	172.5	69	50.26		18.0	23.82	34.46	56.43	32.65	37.12	13.21
	172.5	69		157.0							
1	175.0	70	71.28		17.0	29.33	35.61	56.82	32.37	43.45	13.78
	175.0	70		150.2							
1	177.5	71	68.19		20.0	25.93	39.50	59.58	35.00	40.17	13.47

Table 4   Average skinfold thickness of 95 college women

No. of subj.	Height cm.	Height in.	Weight kg.	Weight lbs.	Age yrs.	Upper arm mm.	Sub-scap-ular mm.	Supra-iliac mm.	Abdomen mm.	Chest mm.	Waist mm.	Thigh mm.	Average skinfold thickness mm.
1	140.0 142.5	56- 57	46.40	102.2	19.0	11.83	14.83	11.83	11.50	7.46	8.82	28.83	123.01
2	147.5 150.0	59- 60	52.40	115.5	18.33	15.94	16.18	10.00	12.67	5.67	9.30	24.16	132.44
3	150.0 152.5	60- 61	59.32	131.1	20.0	15.00	17.30	13.80	11.42	5.16	11.02	22.92	126.22
9	152.5 155.0	61- 62	51.67	113.8	18.1	24.83	18.67	8.83	13.26	7.10	11.32	27.11	144.10
10	155.0 157.5	62- 63	55.17	121.5	18.2	16.74	17.50	15.65	13.60	7.46	9.85	25.60	136.17
14	157.5 160.0	63- 64	55.54	122.6	18.4	14.47	16.63	16.25	12.08	7.27	11.10	24.60	142.00
16	160.0 162.5	64.0- 65	59.66	131.4	18.4	16.50	13.67	18.02	14.63	8.90	10.94	25.64	159.00
14	162.5 165.0	65.0- 66	58.51	121.1	18.6	14.92	14.52	16.48	12.92	8.57	9.31	26.85	133.70
14	165.0 167.5	66.0- 67	60.85	135.0	18.7	15.29	18.79	16.26	10.83	6.67	10.60	24.25	133.87

Table 4 (Continued)

No. of subj.	Height cm.	Height in.	Weight kg.	Weight lbs.	Age yrs.	Upper arm mm.	Sub-scap-ular mm.	Supra-iliac mm.	Abdomen mm.	Chest mm.	Waist mm.	Thigh mm.	Average skinfold thickness mm.
9	167.5 170.0	67-68	60.08	132.3	18.1	15.00	13.34	14.27	12.81	7.83	10.96	25.10	138.14
1	170.0 172.3	68-69	50.26	110.7	18.0	13.61	27.00	13.60	19.00	7.27	7.67	23.00	117.67
1	172.5 175.0	69-70	71.28	157.0	17.0	16.57	15.70	13.30	13.67	6.61	16.83	34.69	173.01
1	175.0 177.5	70-71	68.19	150.2	20.0	20.07	5.00	14.65	9.00	5.00	9.67	23.00	102.34

ference, calf circumference, thigh circumference, bi-iliac diameters, biacromial diameter and average skinfold are shown in Table 5 along with the mean and standard deviation. All pairs of variables but two are positively correlated. The relationship of weight to chest skinfold and age with height are positively correlated.

It should be noted that the relationships hold only with a limited age range for this study of 95 college women, the mean age was 19.06. The average values of skinfold thickness on calf and upper arm circumference has a correlation value of .467 and .466 respectively.

In the present study the relationship of the skinfold thickness to weight was carried out. The present study points at which skinfolds were to be measured and the following conditions were satisfied: 1) representation of regions known to show large variations in subcutaneous fat (abdomen and waist), 2) representation of the extremities (upper arm and thigh measurements),and 3) ease of precise location.

When the individual measures of height and weight were plotted on a scattergram, Figure 2, positive correlation was observed.

The relationship of the height to weight shows the highest correlation of .685. Calf and weight showed the next best relationship, having a correlation value of .609. The relationship of weight to subscapular showed the least correlation.

Interrelationship of Specific Skinfold with Other Variables

Correlation coefficients of specific skinfold and total skinfold thicknesses are given in Table 5. The correlation between the chest

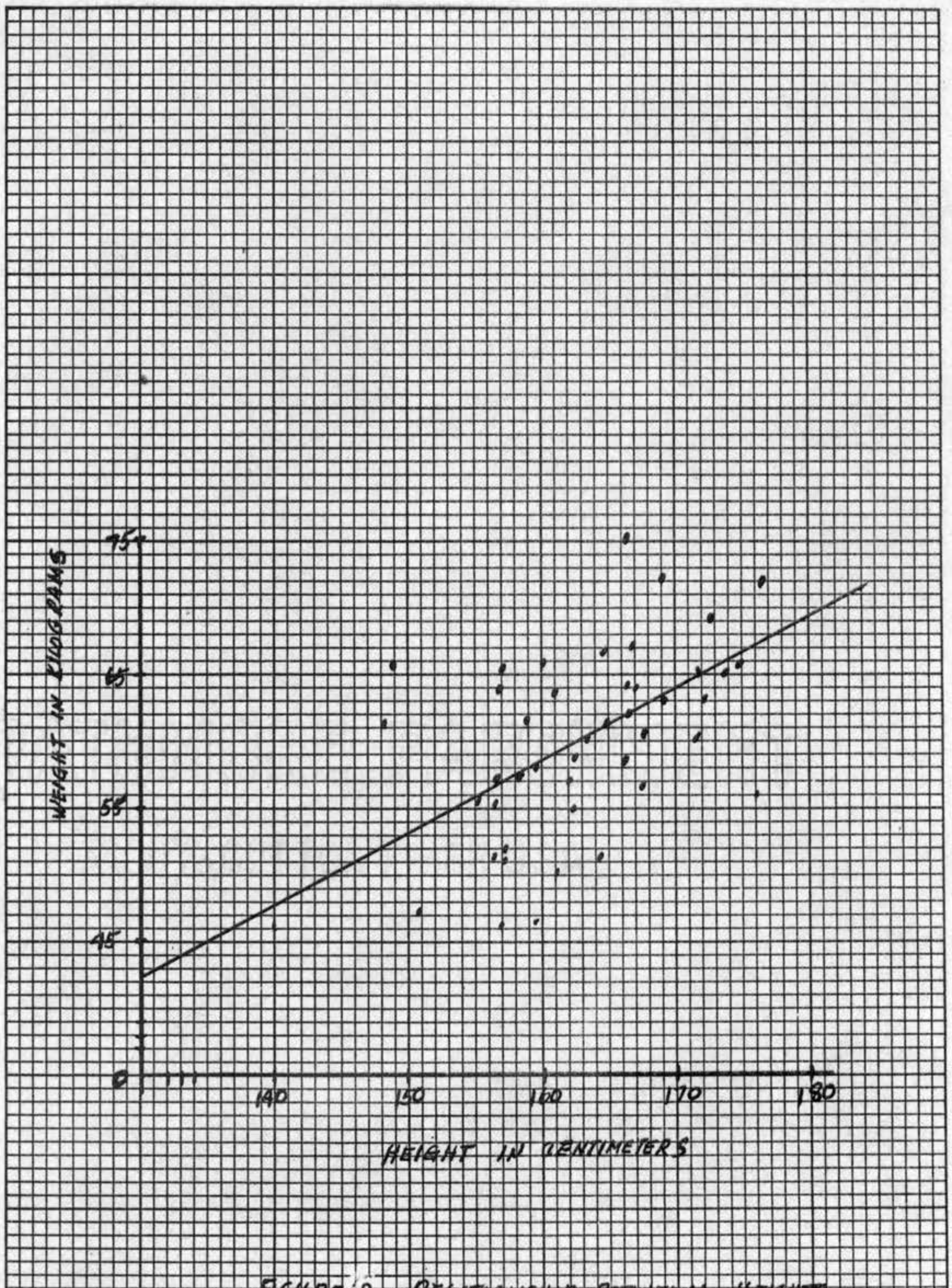


FIGURE 2 RELATIONSHIP BETWEEN HEIGHT AND WEIGHT OF 95 COLLEGE WOMEN WITH THE LINE OF AVERAGE RELATIONSHIP

Table 5 Interrelations between anthropometric and skinfold data of 95 college women

Variables		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}
	Mean	19.06	55.55	162.2	32.05	24.92	26.52	47.80	34.35	10.63	8.77	17.42	11.43	13.62	9.14	23.11	128.50
	Standard Deviation	1.01	5.93	6.23	2.88	2.49	2.02	3.68	2.49	2.53	2.01	4.92	3.99	5.11	2.09	3.97	17.17
X_1 Age	yrs.		.057	-.127	.148	.068	.030	.042	.024	.003	.111	.066	.106	.258	.272	.0461	.116
X_2 Weight	kg.			.685	.279	.505	.4350	.555	.609	.438	.093	.450	.489	.143	-.208	.438	.575
X_3 Height	cm.				.383	.234	.473	.273	.338	.169	.097	.055	.164	.054	.037	.294	.172
X_4 Biacro. diam.	cm.					.125	.152	.269	.162	.003	.135	.012	.016	-.084	.036	.368	.079
X_5 Upper arm circum.	cm.						.129	.449	.387	.403	.294	.376	.333	.106	.194	.326	.466
X_6 Bi-iliac diam.	cm.							.164	.260	.070	.096	.051	.175	.132	.183	.067	.113
X_7 Thigh circum.	cm.								.426	.429	.036	.354	.341	.001	.158	.252	.378
X_8 Calf circum.	cm.									.266	.027	.302	.315	.116	.156	.293	.467
X_9 Upper arm [illegible]	mm.										.247	.471	.521	.123	.447	.321	.637
X_{10} Subscap.	mm.											.205	.113	.094	.381	.067	.245
X_{11} Abdomen	mm.												.631	.390	.345	.356	.811
X_{12} Waist	mm.													.533	.277	.329	.817
X_{13} Supra-iliac	mm.														.029	.335	.631
X_{14} Chest	mm.															.214	.460
X_{15} Thigh	mm.																.618

Table 6 Mean anthropometric measurements of college women classified by states[1]

STUDY	No.	Age Yrs.	Height (cm.) Mean	S.D.[3]	C.V.[4]	Weight (kg.) Mean	S.D.	C.V.	Upper arm circum. Mean	S.D.	C.V.	Calf circum. Mean	S.D.	C.V.
Present Study[2]	95	19.5	162.2	6.28	3.88	55.56	5.92	10.67	10.65	2.53	12.77	34.4	2.46	7.15
Iowa	356	19.5	164.0	6.24	3.81	57.6	7.54	13.08	27.0	2.31	8.57	36.1	2.47	6.84
Kansas	88	19.4	164.8	6.28	3.81	58.4	9.12	15.59	26.6	2.66	10.00	35.8	2.98	8.33
Minnesota	187	19.8	164.2	5.70	3.47	57.5	7.21	12.54	26.7	2.42	9.04	35.7	2.29	6.40
Ohio	160	18.5	161.4	5.90	3.65	55.8	8.12	14.55	26.3	2.60	9.90	35.0	2.45	7.00
Oklahoma	222	18.7	163.2	5.58	3.42	56.5	7.92	14.03	25.7	2.42	9.42	35.4	2.46	6.97

[1] Data, as presented by Donelson (22)

[2] Data for the present study

[3] Standard Deviation

[4] Coefficient of variation

and supra-iliac produced the lowest correlation value, .029. The correlation between the total skinfold and waist is .817, the highest where the total skinfold is a variable. The correlation of the total skinfold and subscapular is .245. The next best correlation was between weight and abdomen, .450; then followed by the weight and upper arm. The least variable correlation was subscapular, supra-iliac and chest skinfold thickness.

As Table 5 denotes, all skinfold variables, show good correlation with one another, the highest being .555 for the relationship between waist and supra-iliac. The lowest is .003, correlation between upper arm and biacromial diameter. The relationship between many other variables is also of the same magnitude.

Comparison of Data Collected with Published Data Anthropometric Measurements Exclusive of Skinfolds

The pattern of distribution of data of this study corresponds to that of Brozek (15). He found, too, that the greatest concentration of each measurement was around the center of classes.

Donelson (22) presented anthropometric measurements of 1013 women located in several different states. A portion of this study was compared with the present study and is presented in Table 7. Only four measurements of Donelson's study were duplicated in the present one -- stature, weight, upper arm circumference, and calf circumference. It was found that the degree of correlation in the same measurement for women in different states was consistently of the same magnitude. There was a noticeable divergence in the degree of correlation between the different measurements taken. The least variable measurement in this study was height which was the same in Donelson's study. The upper arm circumference of this previous study varied from 6.40 to 8.33. It was 5.89 for the present study which was low. Donelson found that the most variable measurement in all states was the weight, the coefficient of variation ranging from 12.54 to 15.59. The coefficient of this study was lower, 6.92.

Donelson (22) classified measurements according to age for 17 to 21 years inclusive and found that there were small progressive increases in mean values for height and weight.

There were several authors who made the same observations. The number of subjects in each age group of the present study did not afford a valid conclusion, but no definite increase in mean height and weight with age was found.

Table 7 shows a comparison of weights for height and age of women of this study and studies by The American Health Association Research Committee (1950), the Association of Life Insurance Medical Directors and Actuarial Society of America (1912), the Metropolitan Life Insurance Company (1938), the Equitable Life Assurance Society of the United States (1940), and the Society of Actuaries (1959), as reported by Hathaway (29). Measurements of the present study were taken with clothing whereas the measurement taken by the study of the American College Health Association was taken without clothing. In order to make all measurements comparable, it would be necessary to subtract a correction factor of 1.5 pounds, since each gown weighed 1.5.

In practically every instance the subjects of the present study

Table 7 Comparison of average body weights for heights and age of various studies[1]

Study	Ht. (cm.)	65	64	63	66	65	61
	Age (yrs.)	17	18	19	20	21	22
Medico Actuarial Standards (Asso. of Life Ins. Div. and Act. Soc. of America) - - 1920		125.0	123.0	121.0	132.0	129.0	117.0
Metropolitan Life Insurance Study - - 1922-34		124.0	122.0	118.0	131.0	127.0	114.0
Equitable Life Assurance Study 1940		123.0	121.0	118.0	127.0	125.0	113.0
American College of Health Asso. Research Committee - - - 1948-50		128.5	124.5	121.5	132.5	128.5	114.5
Society of Actuaries - - 1959		124.0	120.0	116.0	129.0	125.0	112.0
Present Study		--	121.8	119.08	128.71	126.08	115.0

[1] Data, except for the present study, were presented by Hathaway, 1960

weighed less for height and age than the subjects of other studies. Actual measurements are shown in Table 7. In general the present study compared most favorably with the Metropolitan Life Insurance Study. The eighteen-year-olds of the present study with a height of 64 inches, weighed 121.8 pounds as compared with 122.0 pounds of the Metropolitan Life Insurance Study. The weight for height and age of nineteen-year-olds of the present study with a height of 63 inches weighed 119.08. This compares best with the weight of 118.0 pounds reported by the Metropolitan Life Insurance Study. The twenty-two-year-old subjects in this study weighed 115.0 pounds at a height of 61 inches. They were the closest to Equitable Life Assurance Study and the Metropolitan Life Insurance Study.

Many studies used as basis of comparison in this study are of much earlier date. It should be noted that changes in body size of a population do occur and are attributed to many factors. Although there is still disagreement among researchers as to the limits of plasticity of the human organism, changes in body size represent an increase under more favorable environment of the growth potential of the genes (29).

However, a comparison of a recent study by the Society of Actuaries with earlier ones shows no particular trend in height-weight changes.

It might indicate that with similar economic and educational background, weights for heights are similar to those of Hathaway (29).

Skinfold Measurements

Young (65) presented skinfold measurements of 94 white college

Table 8 Comparison of skinfold thickness of Cornell[1] and Oklahoma State University[2] college women

	Skinfold Thickness			
	OSU College Women		Cornell Women	
Site of Measurement	Mean mm.	Standard Deviation mm.	Mean mm.	Standard Deviation mm.
Upper Arm	24.92	2.49	25.43	6.83
Subscapular	8.77	2.01	12.07	4.10
Supra-iliac	13.63	5.11	20.74	8.55
Thorax Front	---	---	22.93	6.60
Chest-Major Pectoralis	9.14	2.10	6.64	2.75
Chin	---	---	7.06	2.25
Waist	11.43	3.10	14.65	6.89
Knee	---	---	11.37	3.80
Thigh	23.12	3.98	32.99	7.98
Chest - Xyphoid Level	---	---	8.67	3.53
Lower Ribs	---	---	10.46	4.12
Abdomen - Half-way from Umbilicus to Pubis	17.43	4.92	33.04	10.43
Total	133.19		206.5	
Average	9.51		17.2	

[1]Skinfold of Cornell women were included in a study by Charlotte Young (65).

[2]Present study.

women. She found that the correlation coefficients between specific skinfolds and total skinfolds were very high. Several correlations were 0.8000 or higher. The lowest was 0.4994. The same correlations for the present study ranged from .8177 - .2454.

Note the comparisons of skinfolds of the two studies in Table 8. Seven of the twelve measurements used in the former study were duplicated in the present one. The upper arm, subscapular, chest, major pectoralis and waist show close resemblance.

Anthropometric and Skinfold Measurements Using Weight as a Criterion for Estimating Leanness-Fatness

Prediction equations for weight using indirect fatness are presented on Table 9.

Logically, considerations of body size appear obviously desirable for the characterization of interindividual differences in leanness-fatness.

The general form of the equation were,

$$\hat{Y} = \beta_0 + \hat{\beta}_1 X_1$$

when,

$\hat{Y}$ = weight

X = skinfold thickness

β_0 = is the intercept

$\hat{\beta}_1$ = slope of regression line

The precision of prediction may be raised by combining several prediction variables.

TABLE 9 Equations for predicting body weight ($\hat{Y}$) from skinfold measurements (X_8-X_{14})

Variate	(Skinfold Values are in mm.)
Skinfolds:	
Upper arm	$50.4519 + 1.4685\ X_8$
Subscapular	$10.9010 + 1.0247\ X_9$
Abdomen	$2.4246 + .2763\ X_{10}$
Waist	$36.4596 + 2.0918\ X_{11}$
Supra-iliac	$8.3003 + .7264\ X_{12}$
Chest	$2.2597 + .1659\ X_{13}$
Thigh	$5.3807 + .5887\ X_{14}$

The general formula is,

$$\hat{Y} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots\dots\dots \beta_{14} X_{14}$$

where the $\hat{Y}$ is the observed weight, β_0 is the intercept, X's are the predicting variable.

Using all predicting variables, from the above equation for predicting total leanness-fatness

$$\hat{Y} = -79.608 + .587 X_1 + .458 X_2 - .0397 X_3 + .139 X_4 + .204 X_5 + .295 X_6 + .527 X_7 + .087 X_8 + .287 X_9 + .169 X_{10} + .167 X_{11} - .029 X_{12} - .133 X_{13} + .133 X_{14}$$

The fourteen predicting variables used in the equation above removed 79.87 per cent of the total sum of squares.

The variable for age contributed very little in the prediction equation. The height variable removed about 50 per cent of the variation. Of all the fourteen variables used, it appears that height, upper arm, thigh, and calf circumference, along with the skinfold thickness of the abdomen were the most important. These five variables removed more than 75 per cent of the sum of squares. It can be seen from the correlation coefficients in Table 5 that if one considers only one of the prediction variables, height would remove $(.685)^2 (100) = 46.9$ per cent of the sum of squares. None of the other variables, when taken alone, would account for as much of the variation.

If one desires to make a critical examination of these fourteen variables in relation to the explained variation in the weight, he might try a step-wise regression technique. This was not done in this study.

CHAPTER V

SUMMARY AND CONCLUSION

Fourteen selected anthropometric measurements were made of 95 college women. The measurements selected were: Height, weight, biacromial and bi-iliac diameters, upper arm, calf and thigh circumferences and seven skinfold measurements. The data showed that:

1. There was no precise increase in weight or any other anthropometric measurements, with an increase in age.
2. The average measurements of the college women of this study with a mean age of 19.06 years were height, 162.2 cm.; weight, 55.56 kg.; biacromial diameter, 32.04 cm.; upper arm circumference, 24.91 cm.; bi-iliac diameter, 26.52 cm.; thigh circumference, 34.35 cm.; calf circumference, 34.35 cm.; average skinfold thicknesses, 74.14 mm.
3. The weight for height and age of the college women of this study agrees with reported data as closely as these published data agree with each other. Therefore, the weight for height and age of the women of this study is comparable to those of standard height-weight-age tables for American women.
4. Several criteria of leanness-fatness were used in the characterization of 95 college women at Oklahoma State University. Frequency distribution of the majority of the anthropometric

measurements tended to group about the mean of the sample.

5. Implication of the data for nutritional research is considered, and the urgent need for extension of this study is suggested by the author in order to observe the same subjects for a period of years. Body fat indicated the most striking variation in state of nutrition. The provision of improved methods for a quantitative estimation of relative body fatness is one of the pressing tasks of nutritional science; it is essential both for the evaluation of calorie nutrition and for the establishment of valid estimates of determining the ratio of lean to fat.

6. It is suggested that further investigation may lead to the use of greater numbers of anthropometric measurements in studying body composition of the age group presented in this study. More detailed anthropometric measurements which might be performed include the length of the upper arm, the forearm, the head, and so on. Longitudinal studies would also be profitable. Then, too, all these things might be tied in with dietary studies and nutritional status.

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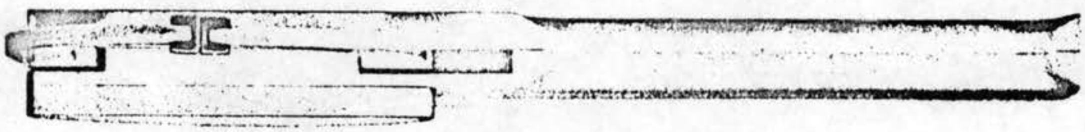
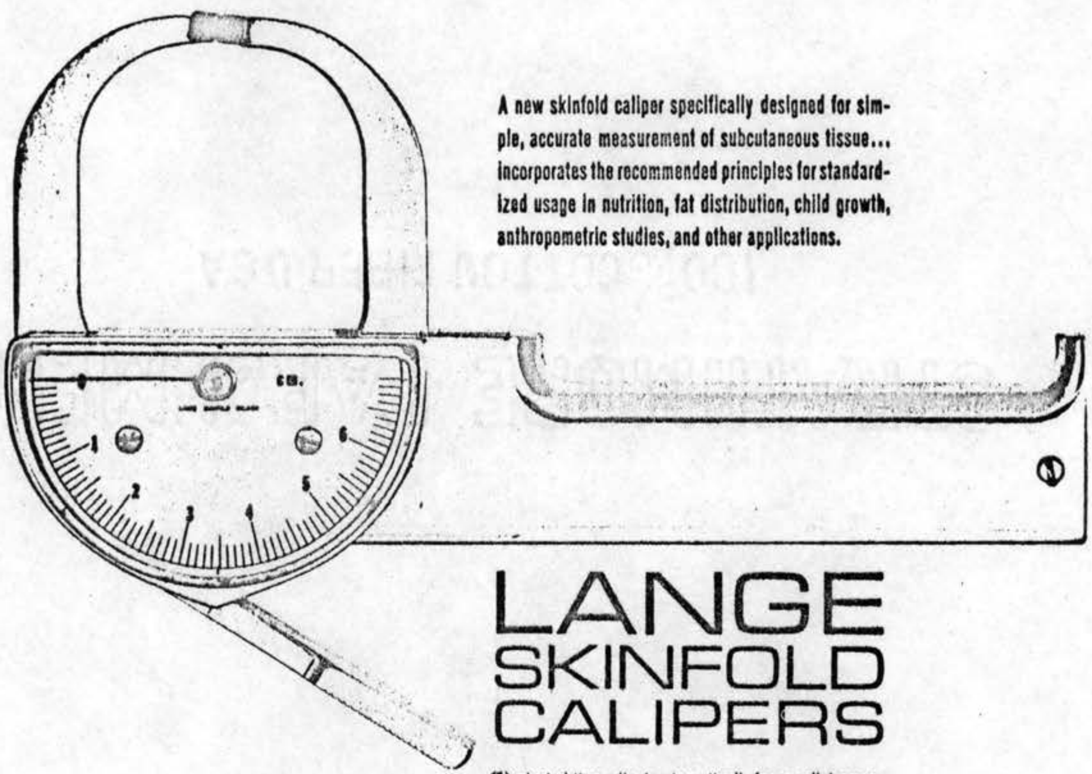
APPENDICES

APPENDIX A





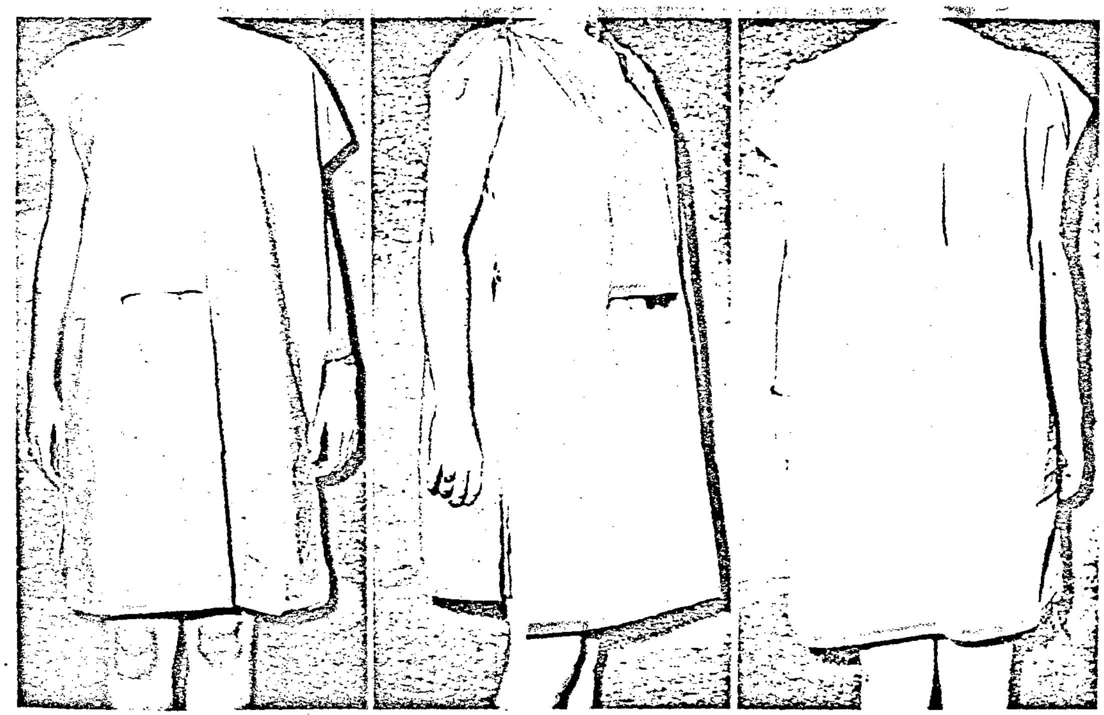
A new skinfold caliper specifically designed for simple, accurate measurement of subcutaneous tissue... incorporates the recommended principles for standardized usage in nutrition, fat distribution, child growth, anthropometric studies, and other applications.

LANGE SKINFOLD CALIPERS

(1) pivoted tips adjust automatically for parallel measurement of skinfolds—rectangular faces with well-rounded edges and corners for patient comfort—face area is approximately 30 mm.^{2} · **(2)** easy-to-read scale permits reading up to 60 mm. accurate to ± 0.5% of full scale. · **(3)** spring-loaded levers provide a substantially constant standard pressure of 10 gm./mm.^{2} over entire operating range—all critical pivot points utilize low friction bearings to maintain accurate tip pressure at all jaw openings · **(4)** sturdy, lightweight construction—anti-corrosive ■ Each unit is supplied in individual case.

CAMBRIDGE SCIENTIFIC INDUSTRIES, INC.
18 Poplar Street · Cambridge, Maryland

APPENDIX B



A gown designed for measuring subcutaneous tissue.

APPENDIX C

4/15/66

OKLAHOMA STATE UNIVERSITY
College of Home Economics

Department of Food, Nutrition and Institution Administration

FORM FOR RECORDING ANTHROPOMETRIC MEASUREMENT

FNIA 500 Thesis Research

Name________________________________ Date______________

Date of Birth____ Mo.___ yr._____ Race______ Nationality__________

Age_____ Weight_____ kg._____ lbs._____ Height_____ in._____ cm._____

Biacromial Diameter _____in. _____cm. Thigh circum. _____in. _____cm.

Upper arm circum. _____in. _____cm. Calf circum. _____in. _____cm.

Bi-iliac circum. _____in. _____cm.

SKINFOLD THICKNESS, mm.

Upper arm _______ Supra-iliac _______

Subscapular _______ Chest _______

Abdomen _______ Thigh _______

Waist _______ COMMENTS:

APPENDIX D

Desirable weights for men and women

Weight in Pounds According to Frame (in indoor clothing)

	HEIGHT (with shoes on) 1-in. heels Feet	Inches	SMALL FRAME	MEDIUM FRAME	LARGE FRAME
	5	2	112–120	118–129	126–141
	5	3	115–123	121–133	129–144
	5	4	118–126	124–136	132–148
DESIRABLE	5	5	121–129	127–139	135–152
	5	6	124–133	130–143	138–156
WEIGHTS	5	7	128–137	134–147	142–161
	5	8	132–141	138–152	147–166
FOR MEN	5	9	136–145	142–156	151–170
	5	10	140–150	146–160	155–174
of ages 25	5	11	144–154	150–165	159–179
	6	0	148–158	154–170	164–184
and over	6	1	152–162	158–175	168–189
	6	2	156–167	162–180	173–194
	6	3	160–171	167–185	178–199
	6	4	164–175	172–190	182–204

	HEIGHT (with shoes on) 2-in. heels Feet	Inches	SMALL FRAME	MEDIUM FRAME	LARGE FRAME
	4	10	92–98	96–107	104–119
	4	11	94–101	98–110	106–122
	5	0	96–104	101–113	109–125
DESIRABLE	5	1	99–107	104–116	112–128
	5	2	102–110	107–119	115–131
WEIGHTS	5	3	105–113	110–122	118–134
	5	4	108–116	113–126	121–138
FOR WOMEN	5	5	111–119	116–130	125–142
	5	6	114–123	120–135	129–146
of ages 25	5	7	118–127	124–139	133–150
	5	8	122–131	128–143	137–154
and over	5	9	126–135	132–147	141–158
	5	10	130–140	136–151	145–163
	5	11	134–144	140–155	149–168
	6	0	138–148	144–159	153–173

For girls 18–25, subtract 1 lb for each year under 25.

METROPOLITAN LIFE INSURANCE COMPANY

APPENDIX E

March 30,1966

Dr. Josef Brozek
Research Professor
Lehigh University
Bethlehem , Penn. 18015

Dear Dr. Brozek :

I am conducting a study on estimating desirable body weight of some college students at Oklahoma State University and I would like to employ the use of some anthropometric measurements. I would like to ask your suggestion as to where I can borrow a caliper.

Thanking you in advance and looking forward to hearing from you.

Sincerely yours,

Marta Garcia

(Miss) Marta Garcia
North Hall
Oklahoma State University
Stillwater, Oklahoma 74075

Dear Friend,

The job you are tackling is tougher than it might appear at first sight.

The calipers can be purchased from the Cambridge Scientific Industries, Inc. 18 Poplar Street, Cambridge, Maryland.

Perhaps the local Health Department has the instrument.

Sincerely, Brozek

Josef Brozek

APPENDIX F

March 1,1966

Committee of Nutritional Anthropometry
Food and Nutrition Board
National Research Council
Wayne State University
Detroit, Michigan

Dear Sirs:

I am currently enrolled in Oklahoma State University for the fulfillment of requirements in a Master's Degree.

I am particularly in need of materials on body weights, which concerns anthropometric data. Since I am going to use anthropometric measurements in my thesis, I have decided to write you to send me some the recent materials. The remittance, kindly send it to me so I can send it back . I would be most appreciative if you could furnish me some materials regarding this matter.

Thanking you in advance and looking forward to hearing from you at your earliest convenience.

Sincerely yours,

(Miss) Marta Garcia
North Hall
Oklahoma State University
Stillwater, Oklahoma 74075

Dear Miss Garcia,
the function of the Committee was terminated in 1956 by the publication of its final report (see Human Biology, Vol. 28, No. 2, March 1956, pp. 107-273). You will find much anthropometric material in this report.

Sincerely B

DR. JOSEF BROZEK
RESEARCH PROFESSOR
LEHIGH UNIVERSITY
BETHLEHEM, PENN. 18015

VITA

Marta Pabustan Garcia

Candidate for the Degree of

Master of Science

Thesis: ANTHROPOMETRIC MEASUREMENTS IN ESTIMATING DESIRABLE BODY WEIGHTS OF SOME FEMALE COLLEGE STUDENTS AT OKLAHOMA STATE UNIVERSITY

Major Field: Food, Nutrition and Institution Administration

Biographical:

Personal Data: Born in Pasay City, Philippines, July 29, 1936, the daughter of Esmeralda Garcia and the late Domingo Garcia, Sr.

Education: Graduated from Far Eastern University High School, Manila, Philippines in 1955; received a Bachelor of Science degree in Foods and Nutrition at the Philippine Women's University in 1959; passed the Civil Service Examination given for nutritionists in December, 1959; completed requirements for Administrative Dietetic Internship at Oklahoma State University in August, 1964.

Professional experience: Nutritionist at Agricultural Credit, Cooperative Financing Administration, 1959-60; assistant laboratory instructor in Foods and Nutrition, The Philippine Women's University, 1960-62; teaching and therapeutic dietitian at Mount Sinai Hospital and Medical School in Chicago, Illinois 1964-66.

Member of Philippine Association of Nutrition, Philippine Association of Home Economics, Philippine Association of University Women, Chicago Dietetic Association, Oklahoma Dietetic Association, American Dietetic Association.