Data from the
NATIONAL HEALTH SURVEY

Series 11
Number 120

Skinfold Thickness of Children 6-11 Years

United States

Three skinfold measurements--triceps, subscapular, and midaxillary--are presented and discussed by age, sex, race, and geographic region for children 6-11 years of age in the United States, 1963-65. Some comparisons are made with children of other countries, and a guide is provided for clinical use of the skinfold measurement by body weight in conjunction with Health Examination Survey weight-by-height tables.

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Series 11 reports present findings from the National Health Examination Survey, which obtains data through direct examination, tests, and measurements of samples of the U.S. population. Reports 1 through 38 relate to the adult program. Additional reports concerning this program will be forthcoming and will be numbered consecutively. The present report is one of a number of reports of findings from the children and youth programs, Cycles II and III of the Health Examination Survey. These reports, emanating from the same survey mechanism, are being published in Series 11 but are numbered consecutively beginning with 101. It is hoped this will guide users to the data in which they are interested.

Vital and Health Statistics - Series 11 - No. 120

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COOPERATION OF THE BUREAU OF THE CENSUS

In accordance with specifications established by the National Health Survey, the Bureau of the Census, under a contractual agreement, participated in the design and selection of the sample, and carried out the first stage of the field interviewing and certain parts of the statistical processing.

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CONTENTS

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SKINFOLD THICKNESS OF CHILDREN 6-11 YEARS, UNITED STATES

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INTRODUCTION

This report of data on skinfold measurements from Cycle II of the Health Examination Survey (HES) is the third one in a series of reports presenting analyses and discussion of body measurements performed in Cycle II. Data on heights, weights, skinfolds, and 25 other dimensions are related to variables such as age, sex, race, geographic region, socioeconomic level of family, IQ, self-concept, school achievement, and skeletal age. The first report[1] analyzed and discussed data of height and weight by age, sex, race, and geographic region of the United States, while the second report[2] carried the analysis and discussion of height and weight data further by considering some measurable socioeconomic variables.

Cycle I of the HES, conducted from 1959 to 1962, obtained information on the prevalence of certain chronic diseases, and on the distribution of a number of anthropometric and sensory characteristics in the civilian, noninstitutionalized population of the continental United States aged 18-79 years. The general plan and operation of the survey and of Cycle I are described in two previous reports[3,4] and most of the results are published in Series 11 reports under the designation PHS Publication No. 1000.

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Cycle II of the HES, conducted from July 1963 to December 1965, involved selection and examination of a probability sample of noninstitutionalized children in the United States aged 6-11 years. This program succeeded in examining 96 percent of the 7,417 children selected for the sample. The examination had two focuses: factors related to healthy growth and development as determined by a physician, a nurse, a dentist, and a psychologist; and a variety of somatic and physiologic measurements performed by specially trained technicians. The detailed plan and operation of Cycle II and the response results are described in another publication.[5]

While height and weight are the basic measurements used to define a normal pattern of growth and development in children, the years since World War II have seen a marked increase in the study of body mass and its components and the application of the results to a variety of problems. Investigators have developed a number of models to express quantitatively the composition of the body through partitioning its weight. Each model has its own set of assumptions and each has been derived with a certain purpose in mind. All, however, are based upon the knowledge that gross body weight is but a very limited measurement of the growing child. Two individuals of the same weight and height may differ strikingly in the amounts of protein, or fat, or even in the inorganic constituents of the skeleton. These differences may reflect the effects of the environment and may serve as fairly sensitive indicators of nutritional deficiency or excess, or of the action of particular diseases.

Many components of body mass, e.g., the distribution of the various trace elements, are relatively constant from one individual to another. On the other hand, body fat varies strikingly among individuals or populations, whether expressed in absolute terms, such as kilograms (kg.), or as a percentage of body weight. Individuals vary normally during their life cycles in the amount of fat they carry; they differ from each other in the patterns of deposition upon and within the body; females, even under optimal dietary conditions, generally display 25 percent more fat, expressed as percentage body weight, than do comparable males.

In other words, there are many sources of variation in normal states of health. In addition, poor environments may drastically alter the amount and deposition of fat; for example, its measurement may accurately reflect the caloric excess of a sample of individuals. Likewise, particular disease processes may alter normal metabolic patterns with consequent effects upon the amount and deposition of fat.

In short, the measurement of body fat presents the investigator with an interpretive tool which can be of great value in research or in the clinical evaluation of individuals.

There are a number of methods currently used to determine the amount of fat carried by an individual.[6-8] Some of these are quite elegant and require expensive and elaborate laboratory procedures. Others are less involved and need little in the way of sophisticated hardware, yet can yield suitably accurate results if performed properly. Of the latter, the measurement of skinfold thickness ranks near the top. Rather than measuring chemically extracted fat, this approach involves the measurement of a double fold of subcutaneous tissue plus skin, pulled away from the underlying tissue by the observer at a predetermined site on the body.

The validity of skinfold measurements rests upon two assumptions: first, that the measurement of the thickness of the subcutaneous layer of fat will reflect suitably the total body fat of an individual; second, that certain sites are correlated well enough with the entire subcutaneous layer so that relatively few measurements will accurately estimate its thickness. Both of these assumptions have been the subject of prolonged and extensive research, but it is not the purpose of this report to review the voluminous scientific literature on the subject. Suffice to say that these assumptions are considered sound enough so that the exceptions to them do not vitiate the use of skinfold measurements in the study of body composition in large population samples. In fact, the taking of skinfolds has distinct advantages. Their measurement does not require elaborate, expensive, or time-consuming procedures. Rather, trained technicians, using standardized calipers, spring loaded to a constant tension to insure a uniform compression of the tissue, are able to measure skinfolds quickly and at an acceptable level of accuracy and replicability—if performed with suitable skill and care. This method is certainly the most applicable to the large-scale studies which are necessary for the determination of within- and between-population studies. It is also the method suited for studies that are conducted away from sophisticated physiological laboratories. Virtually every group which has convened to consider the problem of body composition research and its application has recommended the taking of skinfolds as an integral part of any examination procedure.[9]

A logical sequence of reports of findings of Cycle II of the HES on body measurements has been designed, beginning with a rather straightforward, descriptive presentation of the data in the earliest reports and proceeding through more analytic stages and the examination of various scientific problems. Although a number of topics dealing with body measurements and body composition will eventually be examined, such as childhood obesity and the development of predictive equations of lean body mass, this report is purposely restricted in scope. It presents the distribution of skinfold measurements taken at three different anatomical sites by age, sex, and race of the children and by geographic region of the country. Additionally, some comparisons are made with children of other countries, and a description is given for the clinical use of tables of skinfold distribution by body weight in conjunction with weight-by-height tables from Report No. 104.[1] in this series.

METHOD

At each of 40 preselected locations[b] throughout the United States, the children were brought to the centrally located mobile examination center for an examination which lasted about 2½ hours. Six children were examined in the morning and six in the afternoon. Except during vacations, they were transported to and from school and/or home.

When they entered the examination center, the children's oral temperatures were taken and a cursory screening for acute illness was made. If illness was detected, the child was taken home and reexamined at a later date. The examinees changed into shorts, cotton sweat socks, and a light, sleeveless top and proceeded to different stages of the examination, each one following a different route. There were six different stations where examinations were conducted simultaneously and the stations were exchanged, somewhat like musical chairs, so that at the end of 2½ hours each child had essentially the same examinations by the same examiners but in a different sequence. At three of these stations the children were examined by a pediatrician, a dentist, and a psychologist, and at the other three stations highly trained technicians performed a number of other examinations, including chest and hand-wrist X-rays, hearing and vision tests, respiratory function tests and electrocardiography, an exercise tolerance test on a bicycle ergometer, a battery of body measurements, and a grip strength test.

Included in the anthropometric battery were measurements taken of the thickness of the skin plus subcutaneous tissue at three anatomical sites: (1) *the triceps* (or *upper arm) skinfold,* on the posterior aspect of the upper arm midway between the elbow and the acromial process of the scapula; (2) *the subscapular* (or *infrascapular) skinfold,* on the back immediately below the inferior angle of the scapula; and (3) *the midaxillary* (or *lateral chest wall) skinfold*, on the lateral wall of the chest, in the midline of the axillary region, at the level of the nipple.

All measurements were made on the right side of the subject, if possible, and recorded to the nearest half-millimeter(mm.). Measurements were taken twice, and, where necessary, any discrepancies were resolved by means of a third measurement. In all cases a Lange skinfold caliper was used; this instrument is designed to exert a constant pressure of 10 grams/mm.^{2} throughout the range of jaw openings. The precision of the caliper was tested daily by checking it against metal standards of known widths.

Periodic training sessions were conducted by outside consultants to insure continued proficiency in the measurement techniques and also to obtain replicate data for the purpose of quantifying observer error. The results of the replicate examinations are presented in appendix III, pages 57-60. and more detailed descriptions of the technique of measuring skinfolds and of quality control are given on pages 50-56.

In all of the reports from the HES, age is expressed as the years attained at the last birthday, and the grouping for this report follows this convention. The mean age of each category, therefore, approximates the midpoint of the whole year, e.g., the 8-year-old male group consists of a 1-year cohort whose mean age is 8.51 years, while the corresponding female sample averages 8.49 years. The ages were validated from birth certificates in 95 percent of the subjects; in the remaining cases the age reported by the parent was used.

"Race" was recorded as "white," "Negro," and "other races." The white children comprised 85.69 percent of the total, the Negro children 13.87 percent, and children of "other races" only 0.45 percent. Because so few children were classified as "other races," data from them have not been analyzed separately. These data were included when "total" was used but were dropped when a white-Negro dichotomy was used.

RESULTS

Tables 1-3 present the basic distribution statistics for the total sample broken down into age and sex categories. In addition to the actual and weighted sample sizes, the tables include for each group the mean, standard deviation, standard error of the mean as defined through replication,[c] and the values for seven percentiles from the 5th

[b] See the section The Survey Design in appendix I.

[c] Discussed in the section Parameter and Variance Estimation in appendix I.

through the 95th. All were derived from the weighted sample sizes.

The usual parameters for normal distributions—the mean and its standard error—are included mainly because some investigators continue to use them in their research on skinfolds. At the same time, the nature of the distributions, as clearly indicated by the percentile values, is skewed to the right and suggests that erroneous conclusions may very well result from the use of statistics which assume symmetry in the data. This is especially true in the case of the standard error of the mean; with the marked skewness apparent in the distributions, such measures of dispersion may lead to grossly inaccurate estimates of variation about the mean. For these reasons, the analysis in this report uses the median and other percentiles for most presentations, but it uses the mean and its standard error when additional information may be gained from considering them.

Age Differences

Figures 1-3 depict the distributions of the seven selected percentiles for each age group, by sex. One may note changes in the values from one age to the next; steadily increasing values of almost all of the percentiles with age are evident for all three sites in both boys and girls, the slope of the line being steeper in the case of the higher percentiles. The amount of skewness at the upper end of the distributions tends to increase with age; i.e., at older ages the distance from the 50th to the 95th percentile becomes proportionately greater than that from the 5th to the 50th.

The 95th-percentile values show the greatest absolute change from year to year regardless of site in both males and females. The changes become less and less, as one moves down the percentiles, until the 5th is reached. This level is more or less unchanged from 6 through 11 years.

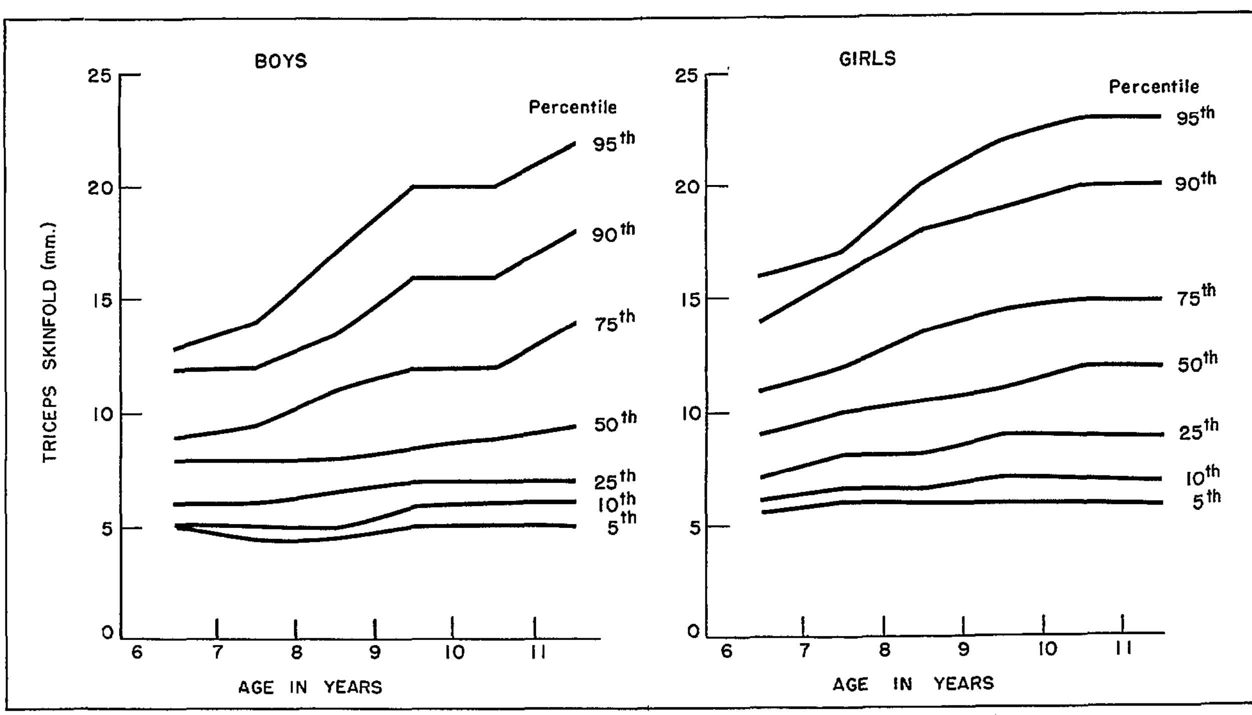

Figure 1. Distribution by selected percentiles of the triceps skinfold of U.S. children, by sex and age.

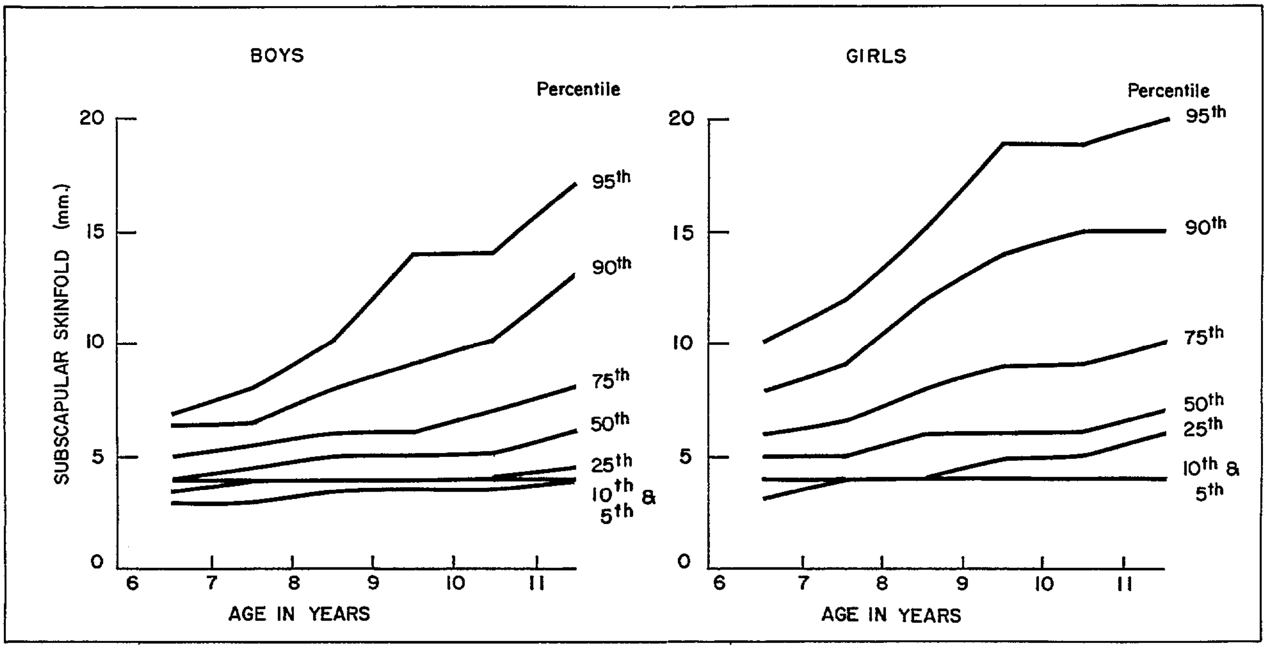

Figure 2. Distribution by selected percentiles of the subscapular skinfold of U.S. children, by sex and age.

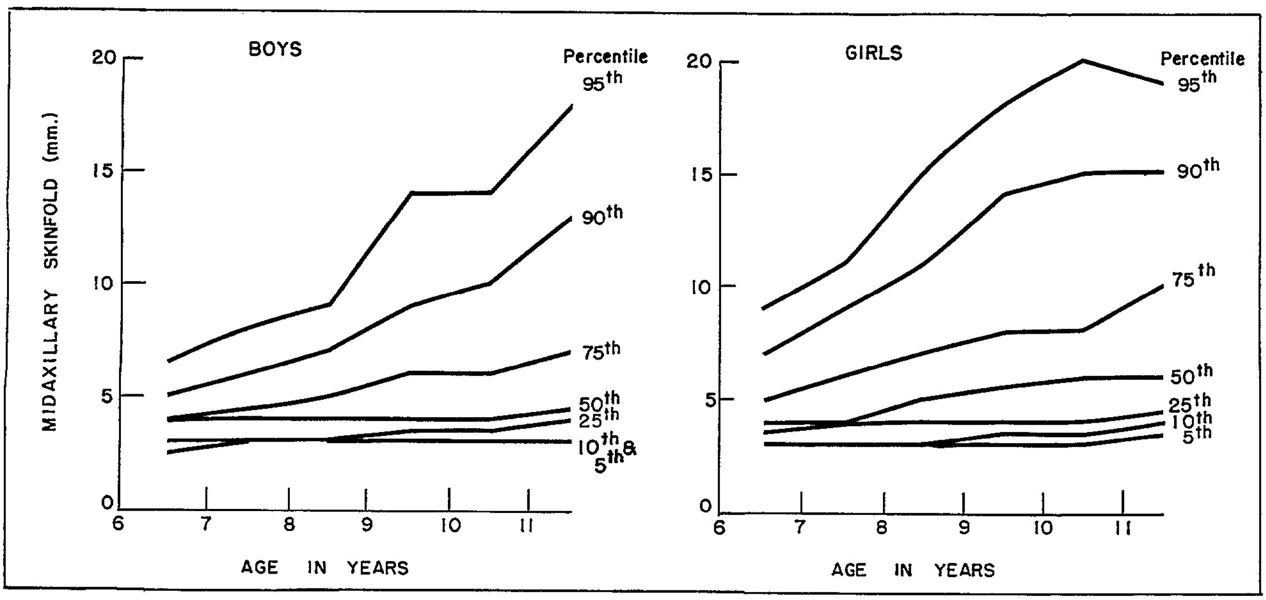

Figure 3. Distribution by selected percentiles of the midaxillary skinfold of U.S. children, by sex and age.

Sex Differences

Figures 4-6 show the median values for each of the three skinfolds for the entire sample. Separate curves for boys and girls are presented to clearly demonstrate the sex differences in skinfolds. Although the values may sometimes be the same for both boys and girls, those for boys are never greater. The medians among girls are approximately 25 percent greater than those of boys of the same age for the same site.

By examining males and females for each of the seven selected percentiles, at each age and site, 126 comparisons are possible (six age categories, seven percentiles, three sites). Of these, girls have values either equal to or greater than, but never less than, those of boys.

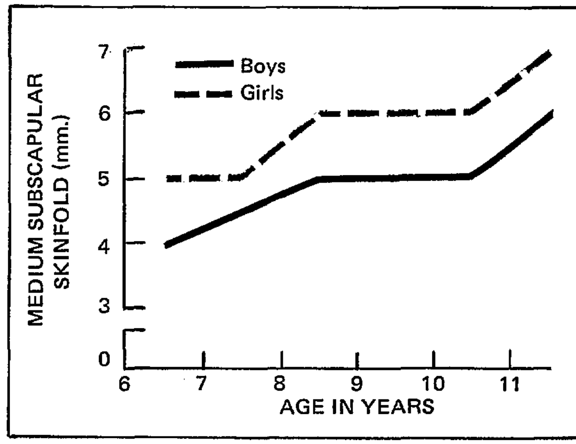

Figure 5. Median subscapular skinfold of U.S. children, by sex and age.

Race Differences

Tables 4-6 present the data in the same basic form as in tables 1-3, but for whites and Negroes separately.[d] A comparison of the medians may be seen graphically in figures 7-9. For any of the three skinfolds, white girls display the highest medians, especially at the triceps and midaxillary sites. At the subscapular site, white girls have medians which are greater than any other group, except Negro girls; the median subscapular skinfolds are the same for both groups at every age except 8 years. Compared to the two male groups, Negro girls have medians for the three skinfolds which exceed those of Negro boys at virtually every age although, in five cases (four of them at the midaxillary site), the values are the same. The medians for Negro girls are greater than or equal to (but never less than) medians

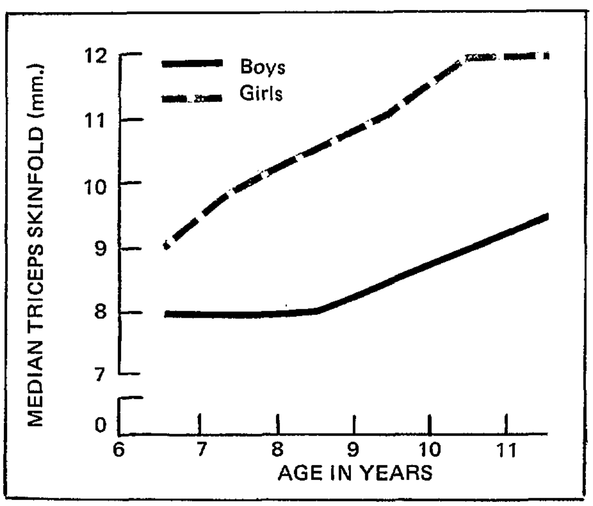

Figure 4. Median triceps skinfold of U.S. children, by sex and age.

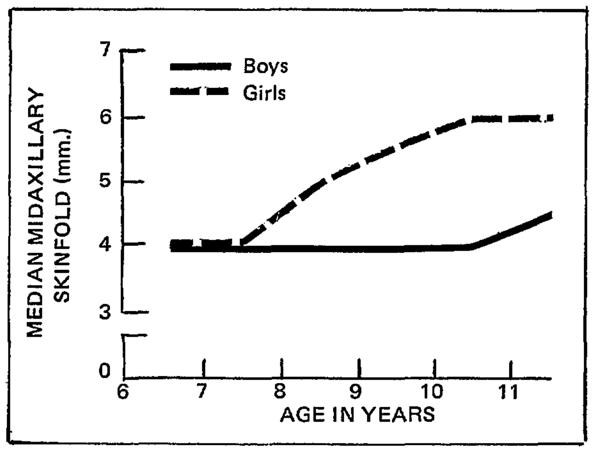

Figure 6. Median midaxillary skinfold of U.S. children, by sex and age.

[d] An interpretation of observed racial differences is given in the Discussion section, later in the report.

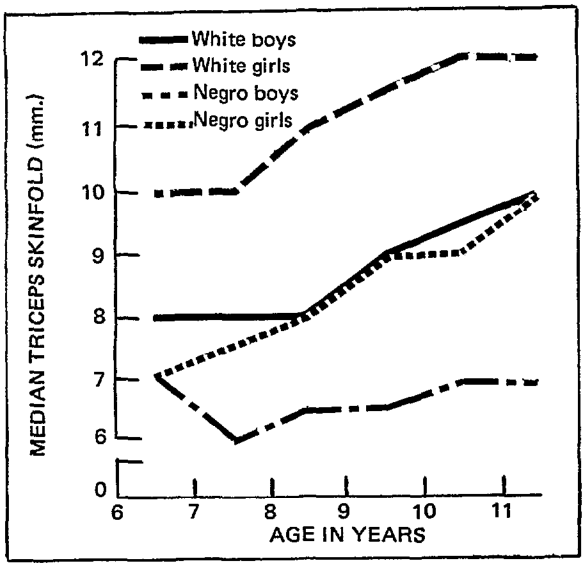

Figure 7. Median triceps skinfold of U.S. children, by race, sex, and age.

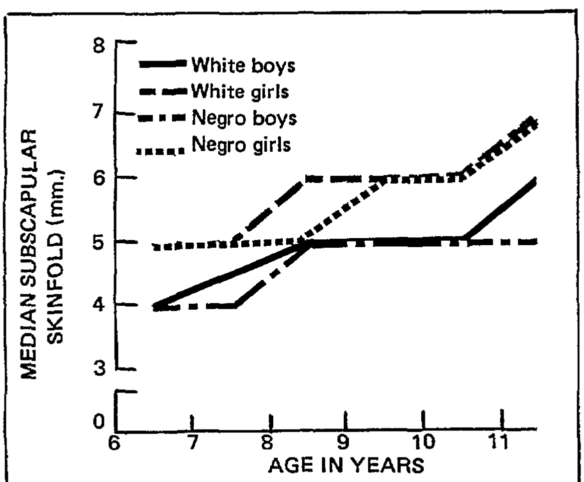

Figure 8. Median subscapular skinfold of U.S. children, by race, sex, and age.

for white boys of the same age at the two trunk sites: the subscapular and midaxillary skinfolds. However, over the triceps muscle, the medians of skinfold thicknesses of Negro girls are either less than or equal to the medians of the white boys.

Thus, it appears that, in the case of limb fat, racial mechanisms are more predominant

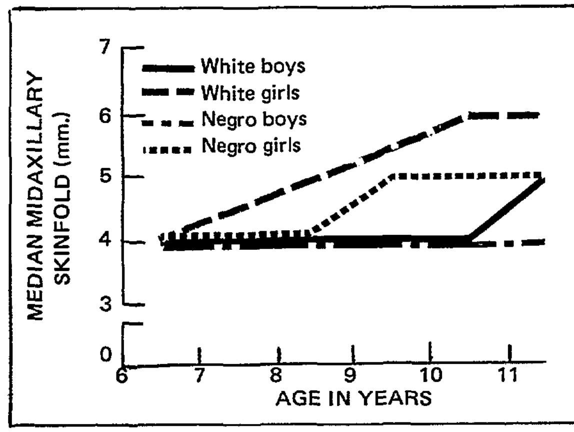

Figure 9. Median midaxillary skinfold of U.S. children, by race, sex, and age.

as determinants of skinfold thicknesses, since white boys have higher medians than do Negro girls—this, despite the greater subcutaneous fat thicknesses associated with females. In contrast, on the trunk, sex mechanisms predominate over racial, since Negro girls have greater median thicknesses for subscapular and midaxillary skinfolds than do white boys.

Negro boys have the lowest medians of all for all three skinfolds, though, in some instances, the values may equal (though never exceed) those of either Negro girls or white boys. In general, only slight change with age is observed among Negro boys of the HES; an extreme example is the midaxillary fold, which has a median thickness of 4.0 mm. for all age groups in the range of the survey.

An examination of the mean skinfolds presented in tables 4-6 shows approximately the same pattern as is seen when the comparisons are based on medians. The means are plotted against age in figures 10-12, and while the sex differences may not be quite as clear cut as when the medians are used (as in figures 7-9), it can be seen that again sex mechanisms are more predominant in trunk fat, while racial mechanisms predominate in the upper arm.

The nature of racial differences in the distribution of skinfolds becomes even more clear by viewing the differences among the means. In general, the differences between the means of white and Negro boys, and between white and Negro girls, are greater than between the medians. In other words, the racial separation is more evident in mean skinfold than in median skinfold thickness. For example, in the case of the subscapular fold, white girls had means higher than those of Negro girls at every age (figure 11); on the other hand, the medians of the two racial groups were equal at five of the six ages (figure 8).

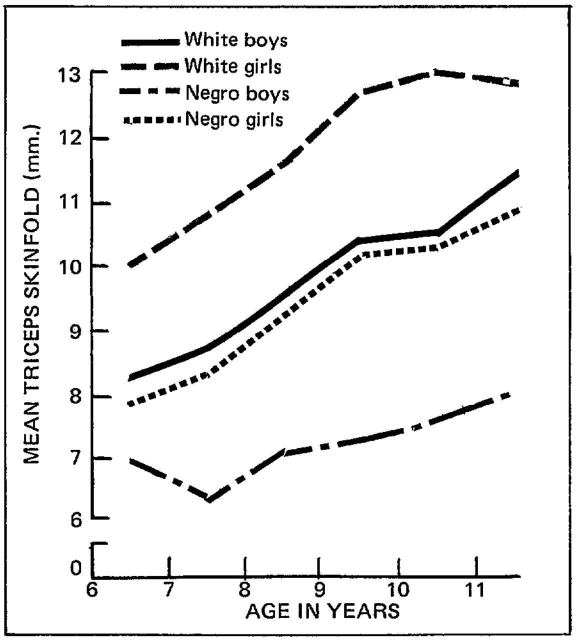

Figure 10. Mean triceps skinfold of U.S. children, by race, sex, and age.

Since the use of the median corrects for distributional skewness to a significant degree, and since the arithmetic mean is affected by skewness, the larger separation between Negroes and whites when the comparisons are based upon the means reflects greater skewness among the skinfold distributions in whites than in Negroes. Examination of the percentile values in tables 4-6 confirms this. The values for Negroes and whites of the same sex are quite similar for subscapular and midaxillary folds at the 5th, 10th, 25th, and 50th percentiles. However, at the 75th, 90th, and 95th percentiles the divergence is quite striking and, in addition, whites have higher values in al-

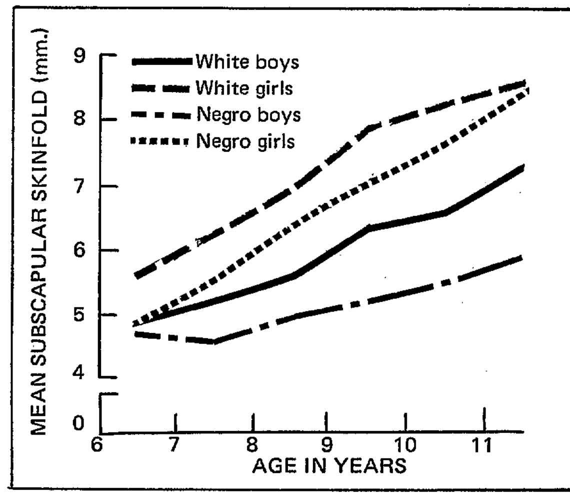

Figure 11. Mean subscapular skinfold of U.S. children, by race, sex, and age.

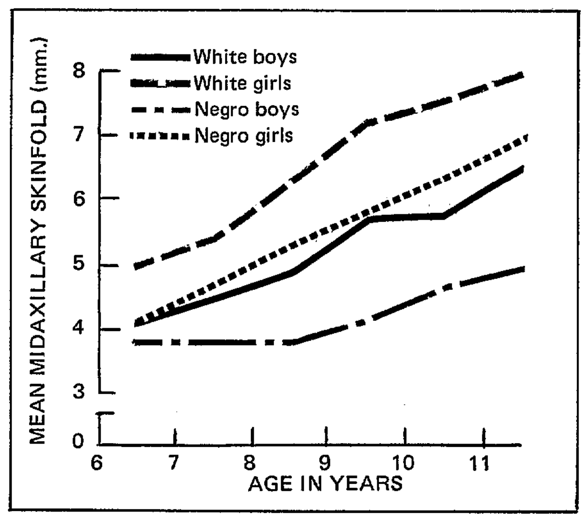

Figure 12. Mean midaxillary skinfold of U.S. children, by race, sex, and age.

most all cases. For example, at the subscapular site, the 10th-percentile value for both Negro and white girls is 4.0 mm., but the 90th-percentile average value for the 6 years in whites is 12 mm. and in Negroes only 10 mm.

Thus, for all three sites, the skinfold distributions are more highly skewed to the right in whites than in Negroes. This appears to be the major (and perhaps the only real) racial difference in trunk fat. For the triceps fold, on the other hand, there are differences at all percentiles. That is, the differences in limb fat, as measured by the triceps skinfold, between whites and Negroes of the same sex exist not only in the degree of skewness, but also in absolute amount. By this reasoning, the larger separations between Negroes and whites (by sex) seen in figures 7 and 10 (limb fat) compared with the smaller differences in figures 8 and 9 and figures 11 and 12 (trunk fat) reflect principally sex-related mechanisms in subscapular and midaxillary skinfolds, reinforced by differences in distributional skewness between the two racial groups. At the triceps site, racial factors predominate and even override sex factors, since white boys tend to have higher values than do Negro girls. These differences are made even larger through the greater skewness in distribution of triceps fat characteristic of whites of both sexes.

Regional Differences

Geographical differences in skinfold thickness may be noted in tables 7-9. The HES sample is broken down into four regions: Northeast, Midwest, South, and West. The differences, where they exist, are numerically small, although a certain consistency may be seen. In almost all of the comparisons the Northeastern, Midwestern, and Southern groups follow a pattern: where a difference in the median values occurs, children from the Northeast display the highest values and children from the South display the lowest. Children from the West do not fall into this pattern, tending to be on the smaller side, in terms of median skinfold thickness, during the earlier years, but having higher medians, relative to the other regions, at 10 and 11 years. In other words, the slope of a line formed by joining the medians would be somewhat greater for Western children than for those from the other three regions.

Correlations Among Skinfolds

The coefficients of correlation among all possible pairs of the three skinfolds were computed for the HES sample and are shown in table 10. The sample was divided into age, sex, and race categories as well as the larger, summary categories.

An examination of table 10 fails to reveal any startling differences. Initially, comparing the correlation coefficients of whites to those of Negroes, it is found that of the 36 comparisons, Negroes had larger values 18 times. Further examination reveals that white boys had larger coefficients than their Negro counterparts 13 of 18 times, while Negro girls had larger coefficients than their white counterparts 13 of 18 times.

Next, a comparison of males and females shows that females had higher correlation coefficients than did males of the same age and race 21 out of 36 times. However, within whites, males scored higher than females 11 of 18 times, while, among Negroes, females scored higher than males 14 of 18 times. Thus, there were no consistent differences in the correlations between sites between either boys and girls, or whites and Negroes.

Since there were no observable patterns or differences in the correlations by age and sex, they could be combined, yielding only three values. These values were quite high, ranging from 0.79 through 0.87. This suggests that at a moment in time, for any child from 6 to 11 years, the thicknesses of the three skinfolds are strongly related in a positive direction. Thus, a child who has greater fat deposits on his arm will likewise have greater deposits on his trunk; the opposite of course is true in the case of the less fat child. Even when the sample was divided into age, sex, and race categories, 30 of the 36 coefficients were greater than 0.70 and all exceeded 0.50.

Even though there is a strongly positive association for all possible pairs of skinfolds, there are also indications that some pairs of skinfolds may be more highly related than others. For the entire sample the correlation between the subscapular and midaxillary skinfolds was the highest at 0.8721, and that between the triceps and midaxillary folds the lowest at 0.7889. The third pairing, triceps and subscapular, yielded the intermediate value, 0.8071.

The consistency of this hierarchy of values was tested by considering the correlations by age, sex, and race. In this way, 24 sets of three r values were available, again as seen in table 10. Utilizing these 24 sets, the following procedure was carried out. Within each set, the pairing which gave the highest correlation was ranked as 3, the lowest as 1, and the intermediate value as 2. For each pair of skinfolds, the ranks were then summed. Since there were 24 sets, if a particular pair were to give the highest *r* value each time, its sum would be 72; if any pair were to always have the lowest ranking, the sum would be 24 (i.e., 24 rankings of 1).

Moreover, if the above ranks were distributed by chance among the three possible pairings (i.e., if there were no association between pairs of skinfolds and rank), the sum of ranks for each pair would be about 48. Therefore, the significance of the deviation of the calculated sum of ranks away from 48 toward either a low of 24 or a high of 72 could be evaluated by the W_n statistic.[e]

The above procedure yielded the following sums of ranks:

subscapular-midaxillary	63
triceps-subscapular	49
triceps-midaxillary	32

This suggests that the highest correlation is between the subscapular and midaxillary skinfolds (the two measures of trunk fat) and the lowest between the triceps and midaxillary; the triceps-subscapular pairing tended to be intermediate between these two. The significance of the deviations from the sums obtained when there was no hierarchy was tested by calculating the W_n statistic which is distributed as chi square; this resulted in a value of 13.10, which, with 2 degrees of freedom, is significant at the .01 level.

Skinfold Distributions by Age and Weight

Although skinfolds are rapidly becoming useful indicators of the growth and development of children, they achieve their greatest utility when considered in conjunction with other growth parameters. Since the ultimate purpose in measuring body fat is to partition total body weight into more meaningful components, skinfolds ought to be considered in relation to body weight. For this reason tables 11-22 present the percentiles for the triceps skinfold by age and sex, by 5 kg. weight categories, where sufficient numbers of subjects have been examined to yield stable percentiles.[f] The presentation here is limited to the triceps skinfold because of its greater utility in obesity studies.

Consider, for example, the examination of two boys, each 8 years of age and with the following dimensions:

	Boy 1	*Boy 2*
Age-----------	8 yr.	8 yr.
Height--------	46 in. (116.8 cm.)	54 in. (137.2 cm.)
Weight--------	45 lb. (20.4 kg.)	75 lb. (34.0 kg.)
Triceps fold--	10 mm.	10 mm.

The examination of each boy might begin with the evaluation of weight-for-height, using the distribution tables for the height and weight of HES children in Report No.104[1] in this series. Table 17 of that report lists weight percentiles by height for 8-year-old boys. Boy number 1, above, with a height of 46 in. and a weight of 45 lb., is near the 50th percentile in weight for that height. However, when one examines table 12 of the present report, the distribution of triceps skinfolds for boys in the above weight category of subject number 1 may be seen: a triceps skinfold of 10 mm. places him at the 95th percentile. Thus, even though weight-for-height might be satisfactory, boy number 1 is among the fattest 8-year-olds of that weight.

If boy number 2 is also evaluated against the national standards of the HES,[1] again utilizing table 17, it may be seen that, for a height of 54 in., his weight of 75 lb. places him very near the 75th percentile in weight-for-height. Again moving to the triceps skinfold-for-weight distributions of the present report, it may be seen from table 14 that,

[e] See the section Analysis of Correlations Among Skinfolds in appendix I.

[f] For criteria determining sufficient numbers of children for a cell, see the section Standards of Reliability and Precision in appendix I.

for his weight and age, a triceps skinfold thickness of 10 mm. places him at the 50th percentile. Boy 1, though not "heavy" (i.e., husky for size, squat, chunky), is "fat"; while boy 2, although "slightly heavy," is not "fat." (This seeming paradox will be examined further in a future report on body composition.)

Thus, an estimate of the degree of fatness becomes another tool which, in conjunction with height and weight, affords greater accuracy for an evaluation of the growth status of individual or groups of children.

DISCUSSION

The use of measures of body fat as indicators of child health and patterns of growth, as population parameters, or as aids in determining the quality of the environment has increased markedly in recent years. Anthropometric measures are serving as indicators of underlying processes of growth and development with increasing frequency. At one time anthropometry was the tool of those individuals more interested in the description of the body than in its underlying processes and control mechanisms. The development of measurements which are concerned with process and which go beneath the mere description of external form, as typified here by body composition measurements, permits a more meaningful study and evaluation of growth processes at the level of the individual and the population of which he is a member.

Because of the relative newness of skinfold measurements as a technique, comprehensive studies of their distribution have yet to accumulate in any number. Almost all of the studies to date have been much narrower in scope, with more restricted sampling and much smaller sample numbers than characterizes the HES.

The data presented in this report constitute the most comprehensive distributions presently available for U.S. children 6-11 years of age. As discussed in appendix III, the utility of the data is strengthened by careful training techniques and attention to quality control; all 7,119 children were measured by a single team of four technicians who remained together for the entire survey. The level of training and performance achieved in this cycle insures that the distributions are as little affected by errors of measurement as it is possible to make them.

The sophisticated sampling techniques insure that the distributions in fact represent those which exist in the U.S. population. The application of statistical weights to the raw sample numbers yields an effective size of 23,784,072 children. Thus, seldom if ever have such elegant sampling techniques and painstaking attention to techniques of measurement been combined in a single scientific study of the growth of children. Whether the resulting data are used as standards of reference in the clinical evaluation of individual children, or epidemiologically in population comparisons, they are as free of extraneous variation as is possible in a study of this magnitude.

The skinfold sites selected for measurement in Cycle II are those usually measured by most other investigators. Hence, maximum comparability to other studies has been afforded. The triceps skinfold, by far the single most frequently taken measurement of adipose tissue, may be used to estimate limb fat, while the subscapular and midaxillary folds are indicators of trunk fat. Since subcutaneous fat thicknesses on the arm and leg are well correlated[10] throughout this age range, the triceps fold thickness will give an adequate measure for the limbs. However, because there is evidence that trunk and limb fat change differentially during growth,[11] it is desirable to have separate estimators of these two body sites.

Age Differences

The skinfold thickness data from Cycle II of the HES indicate that from 6 through 11 years there is a rather steady increase in the medians, and most other percentiles, for fat on both the upper arm and trunk of boys and girls. The exception to this is that, for any age, the values for the leanest 5-10 percent remain about the same. This increase is not unique to American children and may be observed in less advantaged parts of the world as well.[12] However, since subcutaneous fat deposition reflects, among other things, the excess of caloric intake over requirements, the increase in skinfold thickness with age is greater in children with optimal and above-optimal diets such as one often finds in this country.

The distribution of skinfolds at every age shows considerable skewness with a displacement of the curve to the right. While any component of body mass will show this skewness, including body weight itself, fat shows greater asymmetry than most. This presumably indicates that, while there is an absolute lower limit of body fat necessary for the maintenance of body functions, the upper limit may be altered by extrinsic factors, such as diet and exercise, which may affect the energy needs and balance of the body. The marked skewness in fat may be seen, for example, by examining the distribution of subscapular skinfolds in the 11-year-old cohort of girls (table 2). The difference between the 5th and 50th percentiles is only 3.0 mm. (from 4.0 to 7.0), while that between the 50th and 95th is a striking 13 mm. (from 7.0 to 20.0).

With such obvious skewness, investigators should be especially cautious in their selection of measures of central tendency and tests of inference. Parameters which assume a normal distribution have little, if any, meaning, and their use may very well lead to erroneous conclusions. In particular the standard deviation cannot be used to define the middle two-thirds of the distribution, or the true nature of its dispersion will go unnoticed. Thus, individuals cannot be accurately evaluated against standards of reference for subcutaneous fat when the variation about the mean is expressed as standard deviation units. At the same time, the mean itself will be displaced away from the center of the distribution.

There may be times when the means are useful in analyzing skewed distributions. The analysis in this report utilized the means, compared to medians, as indicators of the existence of skewness, although the same could have been done by actually calculating the appropriate statistical moment. As is the case throughout the scientific world, statistics must not be used blindly, but should be applied knowledgeably to specific situations.

Sex Differences

The greater fatness of females has been a matter of record since the onset of body composition research, and was even recognized intuitively before it could be objectively measured. The distributions in tables 1-3 clearly indicate that this sex difference exists during the middle years of childhood. In addition, it is important to realize that differences in the amount of fat exist even between boys and girls of the same body weight. Consider, e.g., table 14, where the distribution of triceps skinfold is presented for children weighing 30-34.9 kg. (66-77 lb). At 7 years of age, the 50th-percentile skinfold in boys is 12 mm. while, in girls, it is 15.5. Similar differences exist at other ages and for other weight categories. Thus, the sex differences in fat reflect true differences in body composition and not just body size variation. The demonstration of this difference by 6 years of age indicates an early genesis and argues against any simplistic explanation based only upon diet, exercise, or other extrinsic factors.

Race Differences

The leanness of American Negroes as compared to American whites has been documented in the past, for example, during childhood by Malina,[13] during preadolescence by Piscopo,[14] and among young adults by Newman.[15] While environmental differences may play a role, the consistency of these findings, even when the environments are more equalized (e.g., among U.S. soldiers, as in Newman's study), suggests genetic mechanisms. The clear existence of subcutaneous fat differences by 6 years of age again points to an early genesis.

The data of the HES provide some additional insights into the nature of the Negro-white differences in skinfold thickness. They demonstrate that racial variation is not the same for all sites, being far more striking for the upper arm than for the trunk. There, white children of either sex, from 6 through 11 years, have skinfolds which are about 25 percent thicker than their Negro age peers. However, at the subscapular and midaxillary sites, the median skinfold thicknesses are not notably different between the two racial groups.

The HES data indicate that differences in trunk fat are to be found principally in the upper percentiles, suggesting that, for appropriate skinfolds, the nature of the racial difference in trunk fat is in the form of the distribution itself. The greater skewness found among whites in the HES data was also found in Newman's study of army recruits.[15] Among these adults and near adults the skinfold values had a narrower distribution among black soldiers than among the white.

Thus, based on the triceps, subscapular, and midaxillary skinfolds, the racial differences may be summarized as follows: trunk fat (subscapular and midaxillary sites) differences are a matter of greater skewness among white children; this affects the higher percentiles (above the median) and, of course, the mean as well. When the entire distribution has not been considered, this effect upon the statistical mean has led, apparently, to the simplistic conclusion that most whites have "more" fat on their trunks than do most Negroes.

On the other hand, limb fat (triceps site) differences are apparent throughout the distribution and may be noted at the lower as well as the higher percentiles. In addition, the same increase in skewness as noted for the trunk is apparent at the upper arm site. The operation of factors which increase fat throughout the distribution, as well as of factors which increase its skewness (thereby affecting the higher percentiles), serves to create even greater differences among the means than one sees for the trunk skinfolds. This is easily seen in figures 10-12.

These observations lead to an interesting speculation regarding the mechanisms underlying differences in subcutaneous fat patterning in whites and Negroes. The differences in the form of the distributions may be attributed to differential environments which skew the distribution more in whites. This could be attributed to a greater excess of calories among more American white children than among American Negro children. On the other hand, the differences in triceps fat which are apparent throughout the distribution may be attributed to hereditary mechanisms operating differentially in the two populations.

If this speculation is correct, then the differences in limb fat between whites and Negroes may be attributed to hereditary and environmental factors, while those in trunk fat are due primarily to environmental factors. Some support for the locus of genetic differences being in the extremities is offered by the observations of other investigators that Negroes and whites differ (also apparently due to genetic mechanisms) in the relative length of the limbs[16] and that they differ in limb musculature as well.[17] However, these speculations about the differences in fat control mechanisms for the trunk and limb must be restricted to children from 6 through 11 years of age.

Regional Differences

Geographical variation in skinfold thickness, though of small magnitude, does exist in the HES sample and seems to follow a generally consistent pattern. The exception to this pattern is to be found in children from the West. Apart from them, however, there is a gradient in skinfold thickness from the Northeast through the Midwest to the South. In general, these regional differences found in skinfolds parallel those in height and weight as discussed in Report No. 104 [1] in this series.

While these geographical differences are rather consistent, they are numerically small and seem to be of little, if any, consequence in the evaluation of individual children. Although the range of geographical variation may reach as high as 2 mm., it is much more commonly found to be in terms of only fractions of a millimeter. Therefore, although the regional differences are real, they are so small that the data of this report may be used clinically without adjusting for geographical region of the children being studied.[g]

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[g]The regional comparisons cannot be considered quite unbiased. Making sharp regional comparisons is not one of the strengths of the HES design for two reasons: (1) The four sampling quadrants of the country (listed in appendix II) were not primarily based on biologic environmental rationale; they represented slight modifications of the existing Bureau of the Census divisions which were necessary for the HES multiple-stage sampling. These divisions were used by HES more for their sampling conveniences than for their epidemiologic convenience. (2) The second reason is logistic. As depicted on a map by McDowell,[5] HES went south in the winter and north in the summer (not simply for the delectation of the staff, but because one good winter snowstorm would have played havoc with the very elaborate advance scheduling). To have standardized for season would have been extremely costly in time and money.

Comparison With Children From Other Countries

Since the thickness of the subcutaneous layer of fat is to a significant degree a function of caloric excess, one would expect to find greater skinfolds among U.S. children, who generally experience a higher nutritional intake than do those of other countries. However, since fatness is also controlled by hereditary mechanisms, any comparisons which cross both national and racial lines must deal with the interactions between genetic and socioeconomic factors.

Even with the above reservation, it is useful to consider some international comparisons. Children of the HES have more fat on the arms, but less on the trunk (based upon median values), than do the London schoolchildren reported on by Scott.[18] The differences are greater for the triceps than the subscapular fold throughout the range of percentiles, as seen in figures 13 and 14. Using Seltzer's criteria of the triceps skinfold as a measure of obesity,[19] this difference between ethnically similar samples may reflect greater nutritional intakes among American children. However, this is only a suggestion; the answer requires more investigation.

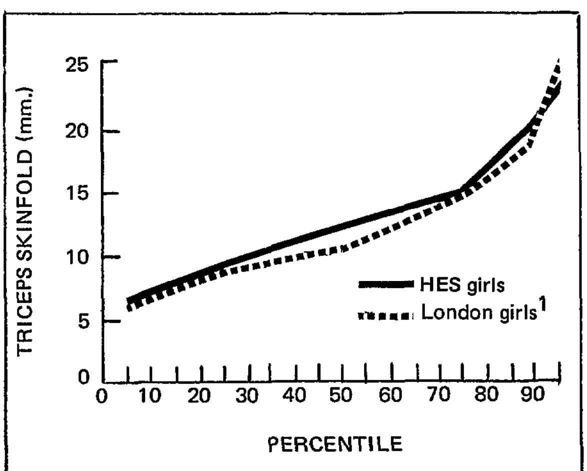

Figure 13. Distribution by selected percentiles of the triceps skinfold of 11-year-old U.S. and English girls.

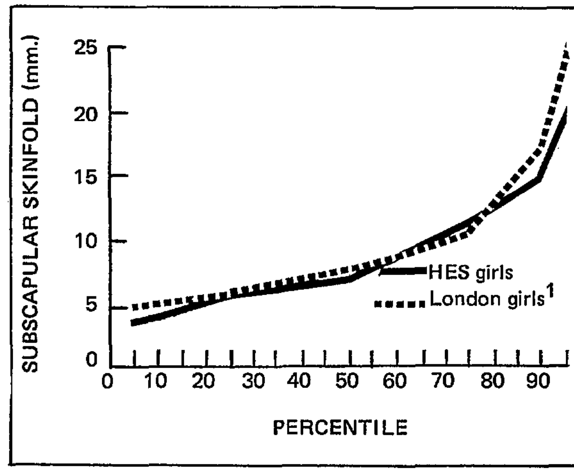

Figure 14. Distribution by selected percentiles of the subscapular skinfold of 11-year-old U.S. and English girls.

U.S. white children have consistently higher skinfolds than children of the same age range from the Peruvian Andes.[20] These differences are in the order of 10-20 percent for the trunk and close to 50 percent for the arm. Again, interpretation of these differences must, of course, remain speculative since, in addition to previous cautions, there is also the problem of the effects upon body fat of life at an altitude greater than 13,000 feet above sea level, characteristic of the Peruvian group.

Another source of comparative data is to be found in the study by Fry *et al.*[12] of over 7,800 Hong Kong boys and girls 6-18 years of age. The children were divided into three socioeconomic groups, though the epidemiological features of each group were not described. Fry transformed the skinfold values into a near normal distribution by the use of logarithms and then used standard statistical measures appropriate for normal distributions to describe the transforms, such as the mean and standard deviation. While one may convert back to the original skinfold by means of the antilog, a precise comparison of these values to the HES medians is not possible and only marked differences can be discussed.

Children of the HES have thicker triceps skinfolds than Chinese boys and girls of the same age regardless of socioeconomic class, the differences being clear cut in both sexes. This held true even for those Hong Kong children classified as being of "high" socioeconomic class, although the epidemiological correlates of this class were not described.

Despite the higher skinfolds at the triceps, the subscapular skinfolds of white children of the HES were not markedly greater and were frequently lower than the antilogs of the upper socioeconomic group of Hong Kong boys and girls.

The meaning of the differences between U.S. and Hong Kong children is even more difficult to assess since the age categories were constructed differently and each group of the Chinese sample was about 6 months older, on the average, than the U.S. children.

It should be obvious that few meaningful statements can be made about differences between the U.S. and Chinese samples, despite large sample sizes, because of differences in analytical procedures. Standardization of methodology is needed if studies are to be comparable.

Correlations Among Skinfolds

As mentioned earlier, the correlations among skinfolds suggest a general "fatness" component, but at the same time, indicate more independence between trunk and limb sites than between the two trunk sites compared to each other. This certainly suggests that, when conducting studies or examining individuals, estimates of both trunk and limb fat provide the greatest amount of information. The absence of significant differences in correlations between skinfold pairs among Negroes and whites, or males and females, indicates that the high relationship found is biologically quite pervasive and not affected by these other variables.

Table 23 compares the correlations between the triceps and subscapular skinfolds, by age, of the HES to those reported by Scott.[18] The higher correlations are to be found among American children; for American Negroes, the r's exceed those of London children 11 of 12 times, while for whites, the higher correlations are found among Americans 10 times.

The correlations reported for the London County Council Survey also differ from those of the HES in that there is an apparent age trend among the former. The values for the correlations tend to rise with age; among American children no age trend is discernible. The values for the HES are very close to those presented by Malina[21] for a smaller sample of American Negroes.

No complete explanation may be offered for the higher correlations between triceps and subscapular skinfold thickness in American children than in their British age peers, nor for the lack of an age trend in the HES data and its presence in the London survey. Both studies were based upon large sample sizes, and the general measurement techniques were generally comparable. One difference is that the British children were measured by technicians using the Harpenden skinfold caliper which reads to the nearest one-tenth of a millimeter, while the Lange caliper, used in the HES, may be read only to one-half of a millimeter, with reliability. How this difference in measurement might have affected the correlation coefficients is unknown.

Another possible explanation lies in the fact that the HES utilized only four technicians, each highly trained before the onset of the study, and all helped by periodic training sessions during its course. Scott's study utilized many more observers who were somewhat less well trained. The increase in error with increased numbers of measurers, because of the greater magnitudes of inter-observer error, relative to intra-observer error, is well known. The increased liability of skinfold measurement to error, especially relative error (i.e., amount of error as a function of magnitude of the measurement), is likewise known. The combination of the two might have led to greater error among the London study with a consequent reduction in the correlations. The further analysis of skinfold data from the HES Survey of Youths 12-17 (Cycle III) may cast some light on these very real differences.

Skinfold Distributions by Age and Weight

The distributions of skinfold thicknesses over the triceps by body weight categories provide investigators with a frame of reference somewhat finer than is allowed if body weight is not considered. The interrelationships of skinfold thickness, body weight, and age are such that all ought to be considered in applying skinfold data to specific problems. While these tables (tables 11-22) do not separate whites and Negroes (not enough of the latter were available in the Cycle II sample for the many cells utilized), they still can be of use in particular situations.

Conclusions

These data, considered as a whole, provide a set of descriptions of the distributions of skinfold thicknesses on the trunk and upper arm of children, separated into age, sex, and race groupings. Because of the nature and comprehensiveness of the sampling techniques, they are representative of the U.S. population 6-11 years old, and unless one were to isolate particular socioeconomic strata, they represent a population enjoying about as high a level of environment as can be examined today. Because of the relatively high caloric intake of American children and because of the value of skinfold thicknesses in nutrition surveys,[22-24] they may be taken as statistically adequate standards of fatness for children with one of the highest caloric intakes in the world.

Finally, this report presents data that constitute the first large-scale standards available on American children during the mid-1960's, providing a basis for more sophisticated and problem-oriented studies yet to come. Taken in conjunction with Cycle I and III of the HES, they should contribute to our knowledge of the state of the physical development of American children and provide a frame of reference for future research in the area of child health.

SUMMARY

This report contains national estimates based on findings from the Health Examination Survey in 1963-65 of three skinfold measurements of children aged 6-11 years.

In this survey a nationwide probability sample of 7,417 children was selected to represent the roughly 24 million noninstitutionalized children 6-11 years of age in the United States. Of these, 7,119 children, or 96 percent, were examined.

Measurement of the three skinfolds of each examinee was part of the standardized examination. All measurements were made with a Lange skinfold caliper and were recorded to the nearest half-millimeter. The triceps skinfold was measured to estimate limb fat, while the subscapular and midaxillary skinfold measurements indicate the amount of trunk fat. A detailed description of the techniques of measurement and quality control procedures is given in one of the appendixes.

For both the limb and trunk there is a rather steady increase in fat for most boys and girls from 6 through 11 years of age. However, amongst the leanest boys (i.e., the leanest 5-10 percent) there is very little change.

Girls generally have skinfolds about 25 percent thicker than those of boys of the same age for the same site. Even among boys and girls of the same body weight, girls have a greater amount of fat. Thus, sex differences in fat are shown to reflect true differences in body composition, not just body size variation.

The data comparing races confirm other studies that American Negroes are leaner than American whites. However, the racial variation is not the same for all sites: the difference is far greater for the limbs than for the trunk. White children of both sexes have upper arm skinfolds which are about 25 percent thicker than those of their Negro age peers, but at the trunk sites the differences are not great.

The fact that white boys have more upper arm fat than do Negro girls—despite the greater subcutaneous fat thicknesses associated with females—suggests that racial mechanisms predominate over sex mechanisms as determinants of limb fat. In contrast, on the trunk, sex mechanisms predominate over racial since Negro girls have thicker subscapular and midaxillary skinfolds than do white boys. These findings, together with the analysis of skewness, led to the speculation that the differences in limb fat between white and Negro children may be attributed to both hereditary and environmental factors, while those in trunk fat may be due primarily to environmental factors, for example, a greater excess of calories among white children.

Small geographical differences were noted in skinfold thickness. Where a pattern exists, children from the Northeast tend to have the largest skinfolds and those from the South the smallest.

Triceps skinfold measurements (the most widely used in obesity studies) are also presented

by 5 kg. body-weight categories to be used, in conjunction with weight-for-height tables in Report No. 104[1] in this series, for evaluating the thickness of the fat layer relative to an individual's height and weight.

The use of the skinfold measurements as standards, both clinical and epidemiologic, is discussed. Considered as a whole, the data may be taken as statistically adequate standards of fatness for children in countries with a high average caloric intake.

U.S. children were found to have thicker skinfolds than do London schoolchildren, children of the Peruvian Andes, and Hong Kong boys and girls. Adequate explanation of these differences would require further investigation.

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LIST OF DETAILED TABLES

Table 1. Triceps skinfold of children by sex and age at last birthday: sample sizes, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1963-65

Sex and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In millimeters									
Boys												
6-11 years	3,632	12,081	9.4	4.28	0.14	5.0	5.5	7.0	8.0	11.0	15.0	18.0
6 years	575	2,082	8.1	2.79	0.17	5.0	5.0	6.0	8.0	9.0	12.0	13.0
7 years	632	2,074	8.4	3.17	0.14	4.5	5.0	6.0	8.0	9.5	12.0	14.0
8 years	618	2,026	9.0	3.77	0.19	4.5	5.0	6.5	8.0	11.0	13.5	17.0
9 years	603	2,012	10.0	4.96	0.28	5.0	6.0	7.0	8.5	12.0	16.0	20.0
10 years	576	1,963	10.1	4.43	0.23	5.0	6.0	7.0	9.0	12.0	16.0	20.0
11 years	628	1,924	11.0	5.32	0.25	5.0	6.0	7.0	9.5	14.0	19.0	22.0
Girls												
6-11 years	3,487	11,703	11.5	4.61	0.15	6.0	7.0	8.0	10.0	14.0	18.0	21.0
6 years	536	2,016	9.7	3.39	0.20	5.5	6.0	7.0	9.0	11.0	14.0	16.0
7 years	609	2,010	10.4	3.61	0.19	6.0	6.5	8.0	10.0	12.0	16.0	17.0
8 years	613	1,960	11.4	4.43	0.17	6.0	6.5	8.0	10.5	13.5	18.0	20.0
9 years	581	1,945	12.3	4.84	0.25	6.0	7.0	9.0	11.0	14.5	19.0	22.0
10 years	584	1,904	12.6	5.12	0.32	6.0	7.0	9.0	12.0	15.0	20.0	23.0
11 years	564	1,868	12.6	5.19	0.25	6.0	7.0	9.0	12.0	15.0	20.0	23.0

NOTE: n = sample size; N = estimated number of children in population in thousands; $\bar{X}$ = mean; s = standard deviation; $s_{\bar{x}}$ = standard error of the mean.

Table 2. Subscapular skinfold of children by sex and age at last birthday: sample sizes, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1963-65

Sex and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
Boys			In millimeters									
6-11 years--	3,632	12,081	5.8	3.41	0.10	3.5	4.0	4.0	5.0	6.0	8.5	13.0
6 years-----------	575	2,082	4.9	1.83	0.10	3.0	3.5	4.0	4.0	5.0	6.5	7.0
7 years-----------	632	2,074	5.1	2.46	0.11	3.0	4.0	4.0	4.5	5.5	6.5	8.0
8 years-----------	618	2,026	5.5	2.90	0.14	3.5	4.0	4.0	5.0	6.0	8.0	10.0
9 years-----------	603	2,012	6.2	3.86	0.21	3.5	4.0	4.0	5.0	6.0	9.0	14.0
10 years----------	576	1,963	6.3	3.79	0.16	3.5	4.0	4.0	5.0	7.0	10.0	14.0
11 years----------	628	1,924	7.1	4.46	0.18	4.0	4.0	4.5	6.0	8.0	13.0	17.0
Girls												
6-11 years--	3,487	11,703	7.1	4.29	0.15	4.0	4.0	4.5	6.0	8.0	12.0	16.0
6 years-----------	536	2,016	5.5	2.67	0.17	3.0	4.0	4.0	5.0	6.0	8.0	10.0
7 years-----------	609	2,010	6.1	3.04	0.20	4.0	4.0	4.0	5.0	6.5	9.0	12.0
8 years-----------	613	1,960	6.9	3.93	0.15	4.0	4.0	4.0	6.0	8.0	12.0	15.0
9 years-----------	581	1,945	7.8	4.93	0.28	4.0	4.0	5.0	6.0	9.0	14.0	19.0
10 years----------	584	1,904	8.1	4.89	0.31	4.0	4.0	5.0	6.0	9.0	15.0	19.0
11 years----------	564	1,868	8.5	4.90	0.26	4.0	4.0	6.0	7.0	10.0	15.0	20.0

NOTE: n = sample size; N= estimated number of children in population in thousands; $\bar{X}$ = mean; s = standard deviation; $s_{\bar{x}}$ = standard error of the mean.

Table 3. Midaxillary skinfold of children by sex and age at last birthday: sample sizes, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1963-65

Sex and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In millimeters									
Boys												
6-11 years--	3,632	12,081	5.1	3.57	0.10	3.0	3.0	3.0	4.0	5.0	8.0	12.0
6 years-----------	575	2,082	4.1	2.01	0.09	2.5	3.0	3.0	4.0	4.0	5.0	6.5
7 years-----------	632	2,074	4.4	3.18	0.12	3.0	3.0	3.0	4.0	4.5	6.0	8.0
8 years-----------	618	2,026	4.8	2.97	0.14	3.0	3.0	3.0	4.0	5.0	7.0	9.0
9 years-----------	603	2,012	5.5	3.91	0.23	3.0	3.0	3.5	4.0	6.0	9.0	14.0
10 years----------	576	1,963	5.6	3.84	0.14	3.0	3.0	3.5	4.0	6.0	10.0	14.0
11 years----------	628	1,924	6.3	4.57	0.22	3.0	3.0	4.0	4.5	7.0	13.0	18.0
Girls												
6-11 years--	3,487	11,703	6.4	4.27	0.15	3.0	3.0	4.0	5.0	7.0	12.0	16.0
6 years-----------	536	2,016	4.9	2.86	0.17	3.0	3.0	3.5	4.0	5.0	7.0	9.0
7 years-----------	609	2,010	5.3	2.86	0.17	3.0	3.0	4.0	4.0	6.0	9.0	11.0
8 years-----------	613	1,960	6.2	3.96	0.14	3.0	3.0	4.0	5.0	7.0	11.0	15.0
9 years-----------	581	1,945	7.0	4.65	0.30	3.0	3.5	4.0	5.5	8.0	14.0	18.0
10 years----------	584	1,904	7.4	4.98	0.36	3.0	3.5	4.0	6.0	8.0	15.0	20.0
11 years----------	564	1,868	7.9	4.97	0.22	3.5	4.0	4.5	6.0	10.0	15.0	19.0

NOTE: n = sample size; N= estimated number of children in population in thousands; $\bar{X}$ = mean; s = standard deviation; $s_{\bar{x}}$= standard error of the mean.

Table 4. Triceps skinfold of children by race, sex, and age at last birthday: sample sizes, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1963-65

Race, sex, and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In millimeters									
WHITE												
Boys 6-11 years-------	3,153	10,391	9.8	4.33	0.15	5.0	6.0	7.0	8.5	11.0	15.5	19.0
6 years------------	489	1,787	8.3	2.82	0.18	5.0	6.0	6.5	8.0	9.5	12.0	13.0
7 years------------	551	1,781	8.7	3.20	0.16	5.0	6.0	7.0	8.0	10.0	12.0	14.5
8 years------------	537	1,739	9.3	3.80	0.20	5.0	6.0	7.0	8.0	11.0	14.0	17.0
9 years------------	525	1,730	10.4	5.06	0.30	5.0	6.0	7.0	9.0	12.0	17.0	21.0
10 years-----------	509	1,692	10.5	4.41	0.22	5.5	6.0	7.5	9.5	13.0	16.0	20.0
11 years-----------	542	1,662	11.5	5.32	0.27	5.5	6.0	8.0	10.0	14.0	19.0	22.0
Girls 6-11 years-------	2,947	10,012	11.8	4.55	0.16	6.0	7.0	8.5	11.0	14.0	18.0	21.0
6 years------------	461	1,722	10.0	3.39	0.21	6.0	6.5	8.0	10.0	11.0	14.0	16.0
7 years------------	512	1,716	10.8	3.47	0.21	6.5	7.0	8.0	10.0	12.5	16.0	18.0
8 years------------	498	1,674	11.7	4.34	0.18	6.0	7.0	9.0	11.0	14.0	18.0	20.0
9 years------------	494	1,663	12.7	4.83	0.28	7.0	8.0	9.0	11.5	15.0	20.0	22.5
10 years-----------	505	1,632	13.0	5.08	0.34	6.0	7.0	9.0	12.0	16.0	20.0	23.0
11 years-----------	477	1,605	12.9	5.07	0.26	7.0	7.5	9.0	12.0	16.0	20.1	22.0
NEGRO												
Boys 6-11 years-------	464	1,642	7.2	3.13	0.22	4.0	4.0	5.0	6.5	8.0	11.0	13.0
6 years------------	84	289	7.0	2.26	0.23	4.0	5.0	5.5	7.0	8.0	10.0	11.0
7 years------------	79	286	6.4	2.14	0.27	4.0	4.0	5.0	6.0	7.0	9.0	10.0
8 years------------	79	279	7.1	2.98	0.34	4.0	4.0	5.0	6.5	8.0	12.0	13.0
9 years------------	74	269	7.2	2.99	0.42	4.0	4.0	5.0	6.5	8.0	11.0	14.0
10 years-----------	65	264	7.6	3.49	0.39	4.0	4.0	5.5	7.0	9.0	11.0	13.0
11 years-----------	83	255	8.1	4.32	0.56	4.0	4.0	6.0	7.0	9.0	12.0	18.0
Girls 6-11 years-------	523	1,629	9.5	4.50	0.17	5.0	5.5	6.5	8.0	11.0	15.0	20.0
6 years------------	72	281	7.9	2.84	0.54	5.0	5.0	6.0	7.0	9.0	11.0	14.0
7 years------------	93	284	8.3	3.68	0.34	5.0	5.0	6.0	7.5	9.0	12.0	16.0
8 years------------	113	281	9.6	4.59	0.28	5.0	5.0	6.5	8.0	11.0	14.0	20.0
9 years------------	84	265	10.2	4.45	0.48	5.0	6.0	7.0	9.0	12.5	15.5	19.0
10 years-----------	77	266	10.3	4.74	0.48	5.0	6.0	7.0	9.0	12.0	20.0	20.2
11 years-----------	84	253	10.9	5.58	0.60	4.0	6.0	7.0	10.0	12.0	20.0	25.0

NOTE: n = sample size; N = estimated number of children in population in thousands; $\bar{X}$ = mean; s = standard deviation; $s_{\bar{x}}$ = standard error of the mean.

Table 5. Subscapular skinfold of children by race, sex, and age at last birthday: sample sizes, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1963-65

Race, sex, and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile 5th	10th	25th	50th	75th	90th	95th
			In millimeters									
WHITE												
Boys 6-11 years-------	3,153	10,391	5.9	3.56	0.11	3.5	4.0	4.0	5.0	6.0	9.0	13.5
6 years------------	489	1,787	4.9	1.90	0.11	3.0	3.5	4.0	4.0	5.0	6.5	7.0
7 years------------	551	1,781	5.2	2.60	0.12	3.0	4.0	4.0	4.5	6.0	7.0	8.0
8 years------------	537	1,739	5.6	3.07	0.17	3.5	4.0	4.0	5.0	6.0	8.0	12.0
9 years------------	525	1,730	6.3	4.07	0.24	3.5	4.0	4.0	5.0	6.0	10.0	15.0
10 years-----------	509	1,692	6.5	3.98	0.17	3.5	4.0	4.0	5.0	7.0	10.5	15.0
11 years-----------	542	1,662	7.3	4.57	0.20	4.0	4.0	4.5	6.0	8.0	14.0	17.5
Girls 6-11 years-------	2,947	10,012	7.2	4.36	0.17	4.0	4.0	4.5	6.0	8.0	12.0	17.0
6 years------------	461	1,722	5.6	2.84	0.19	3.5	4.0	4.0	5.0	6.0	8.0	10.5
7 years------------	512	1,716	6.2	3.07	0.22	4.0	4.0	4.0	5.0	7.0	9.5	12.0
8 years------------	498	1,674	6.9	4.00	0.17	4.0	4.0	4.5	6.0	8.0	12.0	16.0
9 years------------	494	1,663	7.9	5.04	0.33	4.0	4.0	5.0	6.0	9.0	15.0	19.0
10 years-----------	505	1,632	8.2	5.03	0.33	4.0	4.0	5.0	6.0	9.5	16.0	20.0
11 years-----------	477	1,605	8.6	4.85	0.29	4.0	4.0	6.0	7.0	10.0	16.0	20.0
NEGRO												
Boys 6-11 years------	464	1,642	5.1	2.01	0.11	3.0	4.0	4.0	5.0	6.0	7.0	8.0
6 years------------	84	289	4.7	1.38	0.14	3.0	4.0	4.0	4.0	5.0	6.0	6.5
7 years------------	79	286	4.6	1.14	0.16	3.0	4.0	4.0	4.0	5.0	6.0	7.0
8 years------------	79	279	5.0	1.42	0.18	3.0	4.0	4.0	5.0	6.0	6.5	7.0
9 years------------	74	269	5.2	1.57	0.20	3.0	4.0	4.0	5.0	6.0	6.5	8.0
10 years-----------	65	264	5.5	2.12	0.22	3.5	4.0	4.0	5.0	6.0	8.0	12.0
11 years-----------	83	255	5.9	3.41	0.30	3.5	4.0	4.0	5.0	6.0	8.0	14.0
Girls 6-11 years-------	523	1,629	6.6	3.85	0.20	4.0	4.0	4.0	6.0	7.0	10.0	14.0
6 years------------	72	281	4.9	1.07	0.16	4.0	4.0	4.0	5.0	5.5	6.0	7.0
7 years------------	93	284	5.5	2.87	0.29	3.0	4.0	4.0	5.0	6.0	7.0	10.0
8 years------------	113	281	6.4	3.40	0.25	4.0	4.0	4.0	5.0	7.0	10.0	13.0
9 years------------	84	265	7.0	4.25	0.46	4.0	4.0	5.0	6.0	7.0	10.0	14.0
10 years-----------	77	266	7.6	3.93	0.48	4.0	5.0	5.0	6.0	8.0	11.0	12.0
11 years-----------	84	253	8.5	5.28	0.54	4.0	4.0	5.5	7.0	9.0	14.0	20.0

NOTE: n = sample size; N = estimated number of children in population in thousands; $\bar{X}$ = mean; s = standard deviation; $s_{\bar{x}}$ = standard error of the mean.

Table 6. Midaxillary skinfold of children by race, sex, and age at last birthday: sample sizes, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1963-65

Race, sex, and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In millimeters									
WHITE												
Boys 6-11 years-------	3,153	10,391	5.2	3.73	0.11	3.0	3.0	3.0	4.0	5.0	8.0	13.0
6 years-----------	489	1,787	4.1	2.12	0.10	2.5	3.0	3.0	4.0	4.0	5.0	7.0
7 years-----------	551	1,781	4.5	3.39	0.13	3.0	3.0	3.0	4.0	5.0	6.0	8.0
8 years-----------	537	1,739	4.9	3.15	0.17	3.0	3.0	3.0	4.0	5.0	7.0	10.0
9 years-----------	525	1,730	5.7	4.05	0.26	3.0	3.0	3.5	4.0	6.0	10.0	15.0
10 years----------	509	1,692	5.7	3.99	0.16	3.0	3.0	3.5	4.0	6.0	10.0	15.0
11 years----------	542	1,662	6.5	4.68	0.25	3.0	3.0	4.0	5.0	7.0	13.0	18.0
Girls 6-11 years-------	2,947	10,012	6.5	4.37	0.17	3.0	3.0	4.0	5.0	7.0	12.0	16.0
6 years-----------	461	1,722	5.0	3.03	0.18	3.0	3.0	3.5	4.0	5.0	8.0	10.0
7 years-----------	512	1,716	5.4	2.92	0.19	3.0	3.0	4.0	4.5	6.0	9.0	11.0
8 years-----------	498	1,674	6.3	4.04	0.17	3.0	3.0	4.0	5.0	7.0	11.0	15.0
9 years-----------	494	1,663	7.2	4.80	0.35	3.0	3.5	4.0	5.5	8.0	14.0	18.0
10 years----------	505	1,632	7.5	5.04	0.40	3.0	3.5	4.0	6.0	9.0	16.0	20.0
11 years----------	477	1,605	8.0	5.06	0.23	3.5	4.0	5.0	6.0	10.0	16.0	19.0
NEGRO												
Boys 6-11 years-------	464	1,642	4.2	2.02	0.11	3.0	3.0	3.0	4.0	4.0	6.0	7.0
6 years-----------	84	289	3.9	1.13	0.13	3.0	3.0	3.0	4.0	4.0	5.5	6.0
7 years-----------	79	286	3.9	1.24	0.21	2.5	3.0	3.0	4.0	4.0	5.0	6.0
8 years-----------	79	279	3.9	1.17	0.12	3.0	3.0	3.0	4.0	4.5	5.0	6.0
9 years-----------	74	269	4.1	1.47	0.23	3.0	3.0	3.0	4.0	4.0	6.0	7.0
10 years----------	65	264	4.7	2.55	0.22	3.0	3.0	3.0	4.0	5.0	7.0	10.0
11 years----------	83	255	4.9	3.40	0.28	3.0	3.0	4.0	4.0	5.0	6.5	13.0
Girls 6-11 years-------	523	1,629	5.5	3.45	0.17	3.0	3.0	4.0	4.0	6.0	8.0	13.0
6 years-----------	72	281	4.1	1.29	0.18	3.0	3.0	3.0	4.0	5.0	6.0	7.0
7 years-----------	93	284	4.7	2.39	0.21	3.0	3.0	3.0	4.0	5.0	7.0	8.0
8 years-----------	113	281	5.4	3.36	0.22	2.5	3.0	3.0	4.0	6.0	9.0	11.0
9 years-----------	84	265	5.6	3.29	0.34	3.0	3.0	4.0	5.0	6.5	8.0	12.0
10 years----------	77	266	6.3	4.39	0.44	3.0	3.0	4.0	5.0	7.0	10.0	16.0
11 years----------	84	253	7.0	4.30	0.49	3.0	4.0	4.0	5.0	8.0	13.0	16.0

NOTE: n = sample size; N = estimated number of children in population in thousands; $\bar{X}$ = mean; s = standard deviation; $s_{\bar{x}}$ = standard error of the mean.

Table 7. Triceps skinfold of children by geographic region, sex, and age at last birthday: sample sizes, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1963-65

Geographic region, sex, and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
NORTHEAST			In millimeters									
Boys 6-11 years----	893	2,673	10.0	4.48	0.16	5.0	6.0	7.0	9.0	12.0	16.0	20.0
6 years	148	481	8.5	2.60	0.35	5.0	6.0	7.0	8.0	10.0	12.0	14.0
7 years	154	446	8.5	3.05	0.27	5.0	5.5	6.5	8.0	10.0	12.0	13.0
8 years	148	431	10.4	4.62	0.41	5.0	6.0	7.0	9.0	12.0	17.0	20.5
9 years	154	465	10.8	5.14	0.58	5.0	6.0	8.0	9.0	12.0	18.5	24.0
10 years	139	432	10.3	4.23	0.29	5.5	6.0	8.0	9.0	12.0	16.0	20.0
11 years	150	418	11.7	5.67	0.46	5.0	6.0	8.0	10.0	14.0	21.0	23.0
Girls 6-11 years---	889	2,685	12.2	4.85	0.12	6.0	7.0	9.0	11.0	15.0	19.0	22.0
6 years	142	489	10.2	3.49	0.31	6.0	6.5	8.0	10.0	12.0	15.0	17.0
7 years	160	479	11.2	4.08	0.31	6.0	7.0	8.0	10.0	13.5	16.0	18.0
8 years	178	526	11.9	4.69	0.25	6.0	7.0	8.0	11.0	15.0	18.5	20.0
9 years	146	447	13.7	5.44	0.34	7.0	8.0	10.0	13.0	16.0	21.5	25.0
10 years	127	344	13.5	4.81	0.61	6.5	8.0	10.0	12.0	17.0	21.0	22.0
11 years	136	400	13.4	5.40	0.36	7.0	7.0	9.0	12.0	17.0	21.0	24.0
MIDWEST												
Boys 6-11 years----	961	3,428	9.6	4.23	0.09	5.0	6.0	7.0	8.0	11.0	14.5	19.0
6 years	138	530	8.4	2.88	0.20	5.0	6.0	7.0	8.0	9.0	12.0	13.1
7 years	163	570	8.7	3.17	0.20	5.0	6.0	7.0	8.0	10.0	12.0	14.0
8 years	164	589	8.9	3.41	0.17	5.0	5.0	6.5	8.0	11.0	13.0	15.0
9 years	157	568	10.3	5.14	0.47	5.0	6.0	7.5	9.0	12.0	17.5	22.0
10 years	174	621	10.1	4.22	0.28	6.0	6.0	7.0	9.0	13.0	16.0	18.5
11 years	165	550	11.0	5.26	0.50	5.5	6.0	7.0	9.0	13.0	19.0	22.0
Girls 6-11 years---	935	3,336	12.0	4.61	0.26	6.0	7.0	9.0	11.0	14.0	18.5	22.0
6 years	134	509	10.5	3.94	0.23	6.0	6.0	7.5	10.0	12.0	16.0	19.0
7 years	179	632	10.7	3.18	0.34	6.5	7.0	8.0	10.0	13.0	16.0	16.0
8 years	151	522	11.8	4.34	0.31	6.0	7.0	9.0	11.0	14.0	17.0	22.0
9 years	158	574	12.6	4.76	0.58	7.0	7.0	9.0	11.0	15.0	19.0	22.5
10 years	163	546	13.5	5.54	0.55	6.5	7.0	9.0	12.0	16.0	23.0	26.0
11 years	150	554	13.3	4.73	0.37	7.0	8.0	10.0	12.0	16.0	21.0	22.0

NOTE: n = sample size; N = estimated number of children in population in thousands; $\bar{X}$ = mean; s = standard deviation; $s_{\bar{x}}$ = standard error of the mean.

Table 7. Triceps skinfold of children by geographic region, sex, and age at last birthday: sample sizes, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1963-65—Con.

Geographic region, sex, and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In millimeters									
SOUTH												
Boys 6-11 years----	850	2,874	8.9	4.35	0.24	4.0	5.0	6.0	8.0	10.0	14.4	18.0
6 years------------------	144	550	7.8	2.43	0.23	4.5	5.0	6.0	8.0	9.0	10.0	12.0
7 years------------------	147	495	8.1	3.15	0.31	4.0	5.0	6.0	7.0	9.0	12.0	13.0
8 years------------------	145	459	8.4	3.37	0.31	4.0	5.0	6.0	8.0	10.0	12.0	15.0
9 years------------------	146	502	9.1	4.96	0.48	4.0	5.0	6.0	8.0	11.0	15.0	18.0
10 years-----------------	121	427	10.0	5.25	0.49	4.5	5.0	6.0	8.0	11.5	20.0	21.0
11 years-----------------	147	441	10.6	5.60	0.40	5.0	5.5	7.0	8.0	13.0	19.0	23.0
Girls 6-11 years---	857	2,876	10.8	4.65	0.23	5.5	6.0	8.0	10.0	12.0	17.0	20.1
6 years------------------	123	458	9.0	2.99	0.25	5.0	6.0	7.0	8.5	10.5	12.0	14.0
7 years------------------	149	498	10.0	3.88	0.41	5.0	5.5	7.0	9.0	12.0	15.0	19.0
8 years------------------	136	418	10.8	4.15	0.36	6.0	6.0	8.0	10.0	12.0	16.0	20.0
9 years------------------	146	485	11.0	4.33	0.27	6.0	6.0	8.0	10.0	13.0	17.0	20.0
10 years-----------------	148	509	11.9	5.51	0.37	6.0	6.0	8.0	11.0	14.0	20.0	22.0
11 years-----------------	155	508	12.0	5.55	0.69	6.0	6.5	8.0	11.0	14.5	20.0	26.0
WEST												
Boys 6-11 years----	928	3,107	9.2	4.01	0.50	5.0	5.5	6.5	8.0	11.0	14.5	17.0
6 years------------------	145	522	8.0	3.14	0.56	5.0	5.0	6.0	7.0	9.0	12.0	12.5
7 years------------------	168	562	8.2	3.24	0.35	4.5	5.0	6.0	8.0	9.0	11.0	14.0
8 years------------------	161	548	8.6	3.41	0.52	4.5	5.0	6.5	8.0	10.0	13.0	14.5
9 years------------------	146	477	9.6	4.35	0.51	4.0	5.5	7.0	8.5	11.0	16.0	20.0
10 years-----------------	142	483	10.2	4.04	0.72	4.0	6.0	8.0	10.0	12.0	16.0	18.0
11 years-----------------	166	516	11.0	4.76	0.68	5.0	6.0	8.0	10.0	14.0	17.5	20.0
Girls 6-11 years---	806	2,806	10.8	4.13	0.42	6.0	6.0	8.0	10.0	13.0	16.0	20.0
6 years------------------	137	560	9.0	2.80	0.43	5.0	6.0	7.0	8.5	10.0	12.0	15.0
7 years------------------	121	402	9.8	3.07	0.25	6.0	6.5	8.0	9.5	12.0	14.0	15.0
8 years------------------	148	494	11.0	4.38	0.50	5.0	6.0	8.0	10.5	13.0	15.5	20.0
9 years------------------	131	440	12.0	4.37	0.45	7.0	8.0	9.0	11.0	14.0	18.0	22.0
10 years-----------------	146	505	11.9	4.11	0.73	6.0	7.0	9.0	12.0	14.0	18.0	20.0
11 years-----------------	123	405	11.7	4.86	0.73	6.0	7.0	8.0	11.0	14.0	20.0	22.0

NOTE: n = sample size; N = estimated number of children in population in thousands; $\bar{X}$ = mean; s = standard deviation; $s_{\bar{x}}$ = standard error of the mean.

Table 8. Subscapular skinfold of children by geographic region, sex, and age at last birthday: sample sizes, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1963-65

Geographic region, sex, and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In millimeters									
NORTHEAST												
Boys 6-11 years	893	2,673	6.5	3.73	0.25	3.5	4.0	4.5	5.0	7.0	10.0	15.0
6 years	148	481	5.2	1.74	0.20	3.5	3.5	4.0	5.0	6.0	7.0	8.0
7 years	154	446	5.5	2.54	0.29	3.5	4.0	4.0	5.0	6.0	7.0	10.0
8 years	148	431	6.7	4.05	0.49	3.5	4.0	4.0	6.0	7.0	11.0	17.0
9 years	154	465	7.1	4.43	0.64	4.0	4.0	4.5	6.0	7.0	13.0	20.0
10 years	139	432	6.8	3.65	0.28	3.5	4.0	4.5	6.0	7.5	11.0	15.0
11 years	150	418	7.7	4.61	0.50	4.0	4.0	5.0	6.0	8.0	15.0	18.0
Girls 6-11 years	889	2,685	8.0	4.96	0.22	4.0	4.0	5.0	6.0	9.0	14.0	19.0
6 years	142	489	6.2	3.03	0.26	4.0	4.0	4.5	5.5	7.0	8.0	12.0
7 years	160	479	6.9	3.77	0.38	4.0	4.0	4.5	6.0	7.0	11.5	15.0
8 years	178	526	7.5	4.81	0.35	4.0	4.0	4.5	6.0	8.0	14.0	18.0
9 years	146	447	9.6	6.04	0.45	4.0	5.0	6.0	7.0	11.0	20.0	23.0
10 years	127	344	9.3	5.26	0.65	4.0	4.5	6.0	8.0	11.0	16.0	20.0
11 years	136	400	9.6	5.40	0.39	5.0	5.0	6.0	7.5	12.0	18.0	22.0
MIDWEST												
Boys 6-11 years	961	3,428	5.7	3.22	0.12	3.5	4.0	4.0	5.0	6.0	8.0	12.0
6 years	138	530	4.9	1.61	0.11	3.0	3.5	4.0	4.5	5.0	6.5	7.0
7 years	163	570	5.1	2.15	0.12	3.0	4.0	4.0	5.0	5.0	7.0	8.0
8 years	164	589	5.2	2.25	0.20	3.0	4.0	4.0	5.0	6.0	7.0	8.0
9 years	157	568	6.0	4.03	0.35	3.5	4.0	4.0	5.0	6.0	10.0	15.0
10 years	174	621	6.1	3.58	0.25	3.5	4.0	4.0	5.0	6.0	9.5	14.0
11 years	165	550	6.8	4.19	0.24	4.0	4.0	4.0	5.0	7.5	12.0	15.0
Girls 6-11 years	935	3,336	7.3	4.17	0.30	4.0	4.0	5.0	6.0	8.0	12.0	16.0
6 years	134	509	6.0	3.33	0.26	3.0	4.0	4.0	5.0	6.5	9.0	13.0
7 years	179	632	5.9	2.40	0.21	4.0	4.0	4.5	5.0	7.0	8.0	10.0
8 years	151	522	7.0	4.14	0.23	4.0	4.0	4.5	5.5	7.5	12.0	16.0
9 years	158	574	8.0	4.68	0.67	4.0	4.0	5.0	6.0	10.0	15.0	18.0
10 years	163	546	8.6	5.16	0.50	4.0	4.0	5.0	7.0	10.0	17.0	20.0
11 years	150	554	8.1	4.05	0.62	4.0	4.5	6.0	7.0	9.0	14.0	16.5

NOTE: n = sample size; N = estimated number of children in population in thousands; $\bar{X}$ = mean; s = standard deviation; $s_{\bar{x}}$ = standard error of the mean.

Table 8. Subscapular skinfold of children by geographic region, sex, and age at last birthday: sample sizes, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1963-65—Con.

Geographic region, sex, and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In millimeters									
SOUTH												
Boys 6-11 years----	850	2,874	5.7	3.49	0.15	3.5	4.0	4.0	5.0	6.0	8.0	13.0
6 years----------------	144	550	4.6	1.13	0.11	3.5	4.0	4.0	4.0	5.0	6.0	6.5
7 years----------------	147	495	5.1	2.62	0.25	3.0	4.0	4.0	4.0	5.0	6.0	8.0
8 years----------------	145	459	5.2	2.15	0.15	4.0	4.0	4.0	5.0	5.5	7.0	8.0
9 years----------------	146	502	5.8	3.44	0.22	4.0	4.0	4.0	5.0	6.0	8.0	17.0
10 years---------------	121	427	6.5	4.68	0.43	3.0	4.0	4.0	5.0	6.0	13.0	20.0
11 years---------------	147	441	7.2	5.03	0.30	4.0	4.0	4.0	5.0	8.0	14.0	20.0
Girls 6-11 years---	857	2,876	7.0	4.36	0.25	4.0	4.0	4.0	6.0	7.0	12.0	17.0
6 years----------------	123	458	5.1	2.22	0.27	3.0	4.0	4.0	5.0	5.5	6.5	7.5
7 years----------------	149	498	6.3	3.55	0.52	3.5	4.0	4.0	5.0	6.5	10.0	13.0
8 years----------------	136	418	6.5	3.22	0.19	4.0	4.0	4.0	6.0	7.0	11.0	13.0
9 years----------------	146	485	6.7	4.11	0.36	4.0	4.0	4.0	5.5	7.0	11.0	18.0
10 years---------------	148	509	8.1	5.25	0.39	4.0	4.0	5.0	6.0	10.0	16.0	20.0
11 years---------------	155	508	8.8	5.45	0.51	4.0	4.0	6.0	7.0	10.0	16.0	24.0
WEST												
Boys 6-11 years----	928	3,107	5.6	3.17	0.29	3.0	4.0	4.0	4.5	6.0	8.0	11.0
6 years----------------	145	522	4.9	2.55	0.29	3.0	3.0	4.0	4.0	5.0	7.0	8.0
7 years----------------	168	562	4.8	2.49	0.21	3.0	4.0	4.0	4.0	5.0	6.0	7.5
8 years----------------	161	548	5.2	2.73	0.34	3.0	4.0	4.0	4.5	6.0	6.5	8.5
9 years----------------	146	477	5.8	3.32	0.39	3.0	3.5	4.0	5.0	6.0	9.0	12.0
10 years---------------	142	483	6.0	3.20	0.29	3.0	4.0	4.0	5.0	7.0	9.0	10.5
11 years---------------	166	516	6.8	4.01	0.46	4.0	4.0	4.5	6.0	8.0	13.0	18.0
Girls 6-11 years---	806	2,806	6.3	3.38	0.28	3.5	4.0	4.0	5.0	7.0	10.0	12.5
6 years----------------	137	560	4.8	1.51	0.22	3.0	3.5	4.0	4.0	5.5	7.0	7.0
7 years----------------	121	402	5.1	1.70	0.17	3.5	4.0	4.0	4.0	6.0	7.5	8.0
8 years----------------	148	494	6.4	3.01	0.35	3.5	4.0	4.0	6.0	8.0	10.5	12.5
9 years----------------	131	440	7.0	4.22	0.57	4.0	4.0	5.0	6.0	7.0	12.0	16.0
10 years---------------	146	505	6.9	3.46	0.55	4.0	4.0	4.5	6.0	8.0	10.0	14.0
11 years---------------	123	405	7.8	4.50	0.42	4.0	4.0	5.0	6.0	9.0	14.0	18.0

NOTE: n = sample size; N = estimated number of children in population in thousands; $\bar{X}$ = mean; s = standard deviation; $s_{\bar{x}}$ = standard error of the mean.

Table 9. Midaxillary skinfold of children by geographic region, sex, and age at last birthday: sample sizes, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1963-65

Geographic region, sex, and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In millimeters									
NORTHEAST												
Boys 6-11 years----	893	2,673	5.4	3.62	0.24	3.0	3.0	3.0	4.0	6.0	9.0	13.0
6 years------------------	148	481	4.0	1.49	0.17	2.5	3.0	3.0	4.0	4.0	5.0	6.5
7 years------------------	154	446	4.3	2.27	0.21	2.5	3.0	3.0	4.0	5.0	6.0	7.0
8 years------------------	148	431	5.6	3.64	0.38	3.0	3.0	3.5	4.5	6.0	10.0	13.0
9 years------------------	154	465	6.0	4.06	0.63	3.0	3.0	3.5	5.0	6.5	10.0	16.5
10 years-----------------	139	432	5.8	3.86	0.29	3.0	3.0	4.0	4.5	6.0	10.0	14.0
11 years-----------------	150	418	6.7	4.75	0.62	3.0	3.0	4.0	5.0	7.0	13.0	20.0
Girls 6-11 years---	889	2,685	6.9	4.50	0.26	3.0	3.0	4.0	5.0	8.0	13.0	18.0
6 years------------------	142	489	5.3	2.77	0.17	3.0	3.0	4.0	5.0	6.0	8.0	9.0
7 years------------------	160	479	5.6	3.62	0.38	3.0	3.0	4.0	4.0	6.0	10.0	13.0
8 years------------------	178	526	6.4	4.16	0.34	3.0	3.0	4.0	5.0	7.0	12.0	16.0
9 years------------------	146	447	8.0	4.87	0.42	3.0	4.0	5.0	6.0	9.0	15.0	19.0
10 years-----------------	127	344	8.0	4.76	0.61	3.0	4.0	4.5	7.0	10.0	14.0	18.0
11 years-----------------	136	400	8.6	5.59	0.51	4.0	4.0	5.0	6.0	10.0	18.0	21.5
MIDWEST												
Boys 6-11 years----	961	3,428	5.1	3.55	0.22	3.0	3.0	3.0	4.0	5.0	8.0	13.0
6 years------------------	138	530	4.2	2.12	0.18	3.0	3.0	3.0	4.0	4.0	6.0	7.0
7 years------------------	163	570	4.5	2.44	0.19	3.0	3.0	3.0	4.0	5.0	6.5	7.5
8 years------------------	164	590	4.5	2.35	0.23	2.5	3.0	3.0	4.0	5.0	6.0	8.0
9 years------------------	157	568	5.7	4.45	0.54	3.0	3.0	4.0	4.0	6.0	9.0	15.5
10 years-----------------	174	621	5.5	3.99	0.28	3.0	3.0	3.5	4.0	5.0	10.5	14.0
11 years-----------------	165	550	6.3	4.49	0.42	3.0	3.0	4.0	4.0	7.0	14.0	17.0
Girls 6-11 years---	935	3,336	6.8	4.52	0.40	3.0	3.0	4.0	5.0	8.0	12.0	17.0
6 years------------------	134	509	5.5	3.88	0.25	3.0	3.0	3.5	4.0	6.0	9.0	11.0
7 years------------------	179	632	5.5	2.54	0.29	3.0	3.0	4.0	5.0	6.0	8.0	10.0
8 years------------------	151	522	6.3	4.26	0.36	3.0	3.0	4.0	5.0	7.0	11.0	16.0
9 years------------------	158	574	7.4	4.91	0.70	3.0	3.5	4.0	6.0	9.0	16.0	18.0
10 years-----------------	163	546	8.1	5.63	0.93	3.0	4.0	4.0	6.0	9.0	19.0	22.0
11 years-----------------	150	554	8.0	4.58	0.47	4.0	4.0	5.0	6.0	10.0	15.0	18.0

NOTE: n = sample size; N = estimated number of children in population in thousands; $\bar{X}$ = mean; s = standard deviation; $s_{\bar{x}}$ = standard error of the mean.

Table 9. Midaxillary skinfold of children by geographic region, sex, and age at last birthday: sample sizes, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1963-65—Con.

Geographic region, sex, and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In millimeters									
SOUTH												
Boys 6-11 years----	850	2,874	4.8	3.21	0.15	3.0	3.0	3.0	4.0	5.0	7.0	10.0
6 years------------------	144	550	3.8	1.01	0.12	3.0	3.0	3.0	4.0	4.0	5.0	5.0
7 years------------------	147	495	4.2	2.05	0.18	3.0	3.0	3.0	4.0	4.0	6.0	8.0
8 years------------------	145	459	4.3	1.86	0.13	3.0	3.0	3.0	4.0	5.0	6.0	8.0
9 years------------------	146	502	4.9	3.27	0.30	3.0	3.0	3.0	4.0	5.0	7.0	12.0
10 years-----------------	121	427	5.7	4.14	0.37	3.0	3.0	3.0	4.0	6.0	12.0	17.0
11 years-----------------	147	441	6.2	4.91	0.32	3.0	3.0	4.0	4.0	6.0	12.0	19.0
Girls 6-11 years---	857	2,876	6.0	4.13	0.20	3.0	3.0	4.0	4.0	6.0	11.0	15.0
6 years------------------	123	458	4.3	2.38	0.25	3.0	3.0	3.0	4.0	5.0	6.0	7.0
7 years------------------	149	498	5.2	2.83	0.38	3.0	3.0	4.0	4.0	6.0	10.0	13.0
8 years------------------	136	418	5.6	3.43	0.18	3.0	3.0	4.0	4.0	6.0	9.0	13.0
9 years------------------	146	485	5.9	4.22	0.27	3.0	3.0	4.0	4.0	6.0	10.0	17.0
10 years-----------------	148	509	7.1	5.28	0.29	3.0	3.0	4.0	5.0	8.0	14.0	20.0
11 years-----------------	155	508	7.5	4.73	0.52	3.0	4.0	4.0	6.0	9.0	14.0	17.0
WEST												
Boys 6-11 years----	928	3,107	5.1	3.85	0.24	3.0	3.0	3.0	4.0	5.0	7.0	12.0
6 years------------------	145	522	4.3	2.88	0.29	2.5	3.0	3.0	4.0	4.0	5.5	7.0
7 years------------------	168	562	4.6	4.85	0.47	3.0	3.0	3.0	4.0	4.0	6.0	8.0
8 years------------------	161	548	4.8	3.55	0.42	3.0	3.0	3.0	4.0	5.0	6.0	7.0
9 years------------------	146	477	5.4	3.58	0.37	3.0	3.0	3.5	4.0	6.0	10.0	13.0
10 years-----------------	142	483	5.4	3.29	0.27	3.0	3.0	4.0	4.0	6.0	7.5	12.0
11 years-----------------	166	516	6.1	4.18	0.47	3.0	3.5	4.0	4.5	6.0	11.0	16.0
Girls 6-11 years---	806	2,806	5.9	3.75	0.21	3.0	3.0	4.0	4.5	6.5	10.0	14.0
6 years------------------	137	560	4.3	1.80	0.23	3.0	3.0	3.0	4.0	4.5	6.0	7.0
7 years------------------	121	402	4.7	2.16	0.10	3.0	3.0	3.5	4.0	5.0	6.5	8.5
8 years------------------	148	494	6.3	3.79	0.32	3.0	3.0	4.0	5.0	8.0	11.0	14.0
9 years------------------	131	440	6.8	4.25	0.45	3.0	4.0	4.0	5.0	7.0	14.0	17.0
10 years-----------------	146	505	6.5	3.74	0.49	3.0	3.0	4.0	5.0	8.0	11.0	16.0
11 years-----------------	123	405	7.4	5.01	0.43	3.0	4.0	4.0	6.0	8.0	13.5	17.0

NOTE: n = sample size; N = estimated number of children in population in thousands; $\bar{X}$ = mean; s = standard deviation; $s_{\bar{x}}$ = standard error of the mean.

Table 10. Sample sizes and weighted coefficients of correlation for all pairs of the triceps, subscapular, and midaxillary skinfolds of children, by race, sex, and age at last birthday: United States, 1963-65

Race, sex, and age	*n*	*N*	Correlation coefficients: Triceps-subscapular skinfolds	Triceps-midaxillary skinfolds	Subscapular-midaxillary skinfolds
Total, all races[1]	7,119	23,784	.8071	.7889	.8721
White, both sexes	6,100	20,403	.8100	.7891	.8719
Boys	3,153	10,391	.8069	.7873	.8729
Girls	2,947	10,012	.8137	.7891	.8670
Negro, both sexes	987	3,272	.8247	.8116	.8775
Boys	464	1,642	.8095	.7904	.8711
Girls	523	1,629	.7952	.7834	.8730
WHITE					
Boys					
6 years	489	1,787	.7332	.6799	.8639
7 years	551	1,781	.8006	.6819	.6448
8 years	537	1,739	.7806	.7572	.8555
9 years	525	1,730	.8429	.8310	.9191
10 years	509	1,692	.8041	.8019	.8969
11 years	542	1,662	.8233	.8079	.8895
Girls					
6 years	461	1,722	.7361	.6842	.7712
7 years	512	1,716	.6255	.5731	.7823
8 years	498	1,674	.8179	.7618	.8092
9 years	494	1,663	.7447	.8124	.7276
10 years	505	1,632	.8172	.7700	.8027
11 years	477	1,605	.8100	.7981	.9441
NEGRO					
Boys					
6 years	84	289	.7984	.6418	.7837
7 years	79	286	.7318	.7368	.8478
8 years	79	279	.7995	.7405	.8673
9 years	74	269	.8428	.8114	.8788
10 years	65	264	.7980	.7964	.8731
11 years	83	255	.7592	.7626	.8775
Girls					
6 years	72	281	.7582	.6609	.7672
7 years	93	284	.8717	.8160	.9093
8 years	113	281	.8697	.8439	.9167
9 years	84	265	.8463	.8248	.9480
10 years	77	266	.7859	.8202	.7539
11 years	84	253	.8537	.8673	.9014

[1]Includes white, Negro, and other races.

NOTE: *n* = sample size; *N* = estimated number of children in population in thousands.

Table 11. Triceps skinfold of children aged 6-11 years weighing between 15-19.9 kilograms, by sex and age at last birthday: sample sizes, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1963-65

Sex and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In millimeters									
Boys												
6-11 years------	219	774	6.7	1.52	0.12	4.0	5.0	6.0	7.0	8.0	8.5	9.0
6 years---------------	156	563	6.8	1.51	0.12	4.5	5.0	6.0	7.0	8.0	9.0	9.0
7 years---------------	47	158	6.3	1.51	0.27	4.0	4.0	5.0	6.0	8.0	8.0	9.0
8 years---------------	13	43	6.2	1.28	0.41	3.0	5.0	6.0	6.0	7.0	7.5	8.0
9 years---------------	3	8	*	*	*	*	*	*	*	*	*	*
10 years--------------	-	-	-	-	-	-	-	-	-	-	-	-
11 years--------------	-	-	-	-	-	-	-	-	-	-	-	-
Girls												
6-11 years-------	304	1,086	8.0	2.09	0.21	5.0	5.5	6.5	8.0	9.0	11.0	12.0
6 years---------------	190	722	8.0	2.01	0.24	5.0	6.0	6.0	8.0	9.0	11.0	11.0
7 years---------------	84	275	8.3	2.18	0.31	5.5	6.0	7.0	8.0	9.0	10.5	12.0
8 years---------------	24	70	6.4	1.88	0.45	4.0	4.0	5.0	6.0	8.0	8.0	9.0
9 years---------------	5	16	*	*	*	*	*	*	*	*	*	*
10 years--------------	1	3	*	*	*	*	*	*	*	*	*	*
11 years--------------	-	-	-	-	-	-	-	-	-	-	-	-

NOTE: n = sample size; N= estimated number of children in population in thousands; $\bar{X}$ = mean; s = standard deviation; $s_{\bar{x}}$ = standard error of the mean.

Table 12. Triceps skinfold of children aged 6-11 years weighing between 20-24.9 kilograms, by sex and age at last birthday: sample sizes, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1963-65

Sex and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In millimeters									
Boys												
6-11 years	928	3,207	7.5	2.16	0.14	4.0	5.0	6.0	7.0	9.0	10.0	11.5
6 years	328	1,220	8.1	2.31	0.20	5.0	6.0	6.5	8.0	9.0	11.0	12.0
7 years	336	1,080	7.4	1.96	0.09	4.5	5.0	6.0	7.0	8.5	10.0	11.0
8 years	169	578	7.0	1.83	0.13	4.0	5.0	6.0	7.0	8.0	9.0	10.0
9 years	72	251	6.6	2.15	0.39	4.0	4.0	5.0	6.0	8.0	9.5	11.0
10 years	18	65	6.3	1.86	0.73	3.5	4.0	4.0	7.0	8.0	9.0	9.0
11 years	5	14	6.4	1.79	1.00	4.0	4.0	5.0	7.0	8.0	9.0	9.0
Girls												
6-11 years	890	3,050	9.2	2.59	0.13	5.5	6.0	7.0	9.0	10.5	12.0	14.0
6 years	269	1,014	9.7	2.58	0.19	6.0	7.0	8.0	9.5	11.0	13.0	14.5
7 years	310	1,026	9.2	2.44	0.20	6.0	6.0	7.5	9.0	11.0	12.5	13.0
8 years	196	627	8.9	2.80	0.21	5.0	6.0	7.0	9.0	10.0	12.0	15.0
9 years	79	264	8.5	2.36	0.31	5.0	6.0	7.0	8.0	10.0	11.0	13.0
10 years	30	101	8.2	2.17	0.34	5.0	5.0	6.0	8.0	10.0	11.0	12.0
11 years	6	18	7.3	2.69	1.38	4.0	4.0	6.0	8.0	8.0	13.0	13.0

NOTE: n = sample size; N = estimated number of children in population in thousands; $\bar{X}$ = mean; s = standard deviation; $s_{\bar{x}}$ = standard error of the mean.

Table 13. Triceps skinfold of children aged 6-11 years weighing between 25-29.9 kilograms, by sex and age at last birthday: sample sizes, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1963-65

Sex and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In millimeters									
Boys												
6-11 years------	1,013	3,339	8.3	2.73	0.12	5.0	5.0	6.5	8.0	10.0	12.0	13.0
6 years---------------	78	258	10.0	3.50	0.49	4.5	6.0	8.0	9.0	12.0	14.0	17.5
7 years---------------	196	662	9.1	2.65	0.20	6.0	6.0	7.0	9.0	10.0	12.0	14.0
8 years---------------	288	928	8.5	2.57	0.21	5.0	5.5	7.0	8.0	10.0	12.0	13.0
9 years---------------	247	797	8.0	2.63	0.17	5.0	5.0	6.0	8.0	9.0	11.5	13.0
10 years--------------	148	518	7.3	2.15	0.16	4.0	5.0	6.0	7.0	8.0	10.0	11.0
11 years--------------	56	175	6.9	2.30	0.29	4.0	4.0	5.5	6.0	8.0	10.0	12.0
Girls												
6-11 years------	858	2,852	10.6	3.10	0.13	6.0	7.0	8.0	10.0	12.0	15.0	16.0
6 years---------------	54	194	13.0	3.73	0.53	7.0	7.5	11.0	12.5	15.5	18.5	20.0
7 years---------------	157	528	11.9	3.04	0.30	8.0	8.0	10.0	11.0	14.0	16.0	17.0
8 years---------------	243	773	11.0	2.80	0.21	7.0	8.0	9.0	11.0	13.0	14.0	16.0
9 years---------------	213	717	10.1	2.56	0.15	7.0	7.0	8.0	10.0	12.0	13.5	15.0
10 years--------------	138	459	9.1	2.65	0.23	6.0	6.0	7.0	9.0	11.0	12.0	14.0
11 years--------------	53	180	8.1	2.86	0.45	4.0	4.0	6.0	8.0	10.0	11.5	15.0

NOTE: n = sample size; N = estimated number of children in population in thousands; $\bar{X}$ = mean; s = standard deviation; $s_{\bar{x}}$ = standard error of the mean.

Table 14. Triceps skinfold of children aged 6-11 years weighing between 30-34.9 kilograms, by sex and age at last birthday: sample sizes, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1963-65

Sex and age	n	N	$\bar{X}$	s	$s_{\bar{X}}$	Percentile 5th	10th	25th	50th	75th	90th	95th
			In millimeters									
Boys												
6-11 years------	691	2,312	9.5	3.12	0.15	6.0	6.0	7.0	9.0	11.0	14.0	15.5
6 years---------------	9	29	13.7	2.85	1.17	10.0	10.0	12.0	13.0	17.0	18.0	18.0
7 years---------------	40	136	11.5	3.92	0.84	6.0	7.0	8.5	12.0	14.0	17.0	19.0
8 years---------------	104	336	10.8	3.46	0.44	6.0	7.0	8.0	10.0	13.0	16.0	17.0
9 years---------------	160	569	9.8	2.97	0.27	6.0	6.5	8.0	9.0	11.0	14.0	15.5
10 years--------------	204	688	9.1	2.69	0.21	6.0	6.0	7.0	9.0	10.5	12.0	14.0
11 years--------------	174	555	8.3	2.56	0.21	5.0	6.0	6.0	8.0	10.0	12.0	13.0
Girls												
6-11 years------	584	1,941	12.1	3.71	0.13	7.0	8.0	9.0	12.0	14.0	17.0	19.0
6 years---------------	14	52	17.0	2.52	0.69	14.0	14.0	16.0	16.5	19.0	20.0	20.0
7 years---------------	45	136	15.5	3.38	0.48	10.0	11.5	13.0	15.5	18.0	20.0	22.0
8 years---------------	92	313	14.1	3.43	0.44	9.0	10.0	12.0	13.0	16.0	20.0	21.0
9 years---------------	149	503	12.3	3.30	0.30	8.0	8.0	10.0	12.0	14.0	17.0	18.0
10 years--------------	151	494	11.2	3.18	0.26	6.0	7.0	9.0	11.0	13.0	15.0	18.0
11 years--------------	133	442	9.8	2.90	0.30	6.0	7.0	8.0	9.0	11.0	13.0	15.0

NOTE: n = sample size; N = estimated number of children in population in thousands; $\bar{X}$ = mean; s = standard deviation; $s_{\bar{X}}$ = standard error of the mean.

Table 15. Triceps skinfold of children aged 6-11 years weighing between 35-39.9 kilograms, by sex and age at last birthday: sample sizes, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1963-65

Sex and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
Boys			In millimeters									
6-11 years------	422	1,348	11.5	3.97	0.23	6.0	7.0	8.0	11.0	14.0	17.0	19.0
6 years---------------	2	6	*	*	*	*	*	*	*	*	*	*
7 years---------------	8	23	18.3	2.72	1.09	16.0	16.0	16.0	16.0	19.0	22.0	24.0
8 years---------------	30	91	15.7	3.91	0.63	10.0	11.0	13.0	16.0	18.0	21.0	22.0
9 years---------------	71	220	13.1	3.78	0.48	8.0	8.0	11.0	12.0	16.0	20.0	20.0
10 years--------------	123	422	11.4	3.41	0.31	7.0	8.0	9.0	11.0	14.0	16.0	17.0
11 years--------------	188	585	9.9	3.35	0.25	6.0	6.0	8.0	9.0	12.0	15.0	17.0
Girls												
6-11 years------	377	1,252	14.0	4.58	0.27	7.0	8.0	11.0	13.0	17.0	20.0	23.0
6 years---------------	5	18	23.2	2.80	1.50	19.0	19.0	21.5	25.0	26.0	26.0	26.0
7 years---------------	9	33	19.3	2.92	1.19	12.0	18.0	18.0	19.0	20.0	23.0	26.0
8 years---------------	33	104	18.3	5.34	1.01	10.0	11.5	14.0	18.5	21.0	26.0	27.0
9 years---------------	67	213	16.3	3.74	0.53	11.0	13.0	13.0	16.0	18.0	21.0	22.5
10 years--------------	129	427	13.6	3.92	0.46	7.0	8.0	12.0	13.0	16.0	19.0	20.0
11 years--------------	134	457	11.6	3.34	0.28	7.0	8.0	9.0	12.0	13.0	16.0	17.0

NOTE: n = sample size; N = estimated number of children in population in thousands; $\bar{X}$ = mean; s = standard deviation; $s_{\bar{x}}$ = standard error of the mean.

Table 16. Triceps skinfold of children aged 6-11 years weighing between 40-44.9 kilograms, by sex and age at last birthday: sample sizes, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1963-65

Sex and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In millimeters									
Boys												
6-11 years------	169	525	15.1	4.76	0.46	8.0	9.5	12.0	15.0	18.0	21.0	23.0
6 years---------------	1	3	*	*	*	*	*	*	*	*	*	*
7 years---------------	1	2	*	*	*	*	*	*	*	*	*	*
8 years---------------	6	24	19.1	4.03	2.34	12.5	12.5	17.5	17.5	23.0	24.0	24.0
9 years---------------	25	80	18.2	4.84	1.13	12.0	12.0	15.0	16.5	22.0	25.0	25.0
10 years--------------	51	170	15.5	4.01	0.80	8.0	11.0	12.5	15.0	19.0	21.0	22.0
11 years--------------	85	246	13.2	4.23	0.45	7.0	8.0	10.0	12.5	16.0	19.0	21.0
Girls												
6-11 years------	219	693	15.9	5.17	0.41	8.0	9.0	12.0	15.5	20.0	23.0	25.0
6 years---------------	-	-	-	-	-	-	-	-	-	-	-	-
7 years---------------	3	9	*	*	*	*	*	*	*	*	*	*
8 years---------------	18	55	20.0	4.56	1.09	12.5	13.0	17.0	20.0	24.0	26.0	30.0
9 years---------------	35	109	18.1	5.22	1.02	8.0	10.0	15.0	18.0	22.0	24.0	26.0
10 years--------------	69	214	16.6	5.11	0.55	8.0	10.0	14.0	16.0	20.0	24.0	25.0
11 years--------------	94	306	13.8	4.27	0.52	7.0	9.0	11.0	14.0	16.0	20.0	22.0

NOTE: n = sample size; N = estimated number of children in population in thousands; $\bar{X}$ = mean; s = standard deviation; $s_{\bar{x}}$ = standard error of the mean.

Table 17. Triceps skinfold of children aged 6-11 years weighing between 45-49.9 kilograms, by sex and age at last birthday: sample sizes, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1963-65

Sex and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In millimeters									
Boys												
6-11 years------	97	305	17.5	5.45	0.56	9.0	11.0	12.5	17.0	22.0	25.0	26.5
6 years---------------	1	3	*	*	*	*	*	*	*	*	*	*
7 years---------------	4	12	*	*	*	*	*	*	*	*	*	*
8 years---------------	6	18	21.8	2.68	1.47	17.0	17.0	20.5	22.0	25.0	25.0	25.0
9 years---------------	12	43	21.9	6.13	2.66	12.0	12.5	18.5	22.0	26.0	30.0	30.0
10 years--------------	14	43	18.1	4.34	0.92	12.0	12.0	14.0	18.0	22.0	24.0	24.0
11 years--------------	60	185	15.3	4.38	0.63	8.0	10.0	12.0	15.0	18.0	21.0	23.0
Girls												
6-11 years------	134	435	18.0	5.37	0.62	9.0	11.0	14.0	18.0	22.0	24.5	27.0
6 years---------------	-	-	-	-	-	-	-	-	-	-	-	-
7 years---------------	1	3	*	*	*	*	*	*	*	*	*	*
8 years---------------	6	15	22.3	2.69	1.42	18.0	18.0	20.5	23.0	24.0	26.0	26.0
9 years---------------	25	102	21.2	4.50	0.80	15.0	16.0	18.0	20.0	24.5	27.0	29.0
10 years--------------	37	113	18.9	4.43	0.90	12.0	12.0	15.0	20.0	22.0	24.0	26.0
11 years--------------	65	202	15.3	4.90	0.72	8.0	9.0	12.0	14.0	19.0	22.0	24.0

NOTE: n = sample size; N = estimated number of children in population in thousands; $\bar{X}$ = mean; s = standard deviation; $s_{\bar{x}}$ = standard error of the mean.

Table 18. Triceps skinfold of children aged 6-11 years weighing between 50-54.9 kilograms, by sex and age at last birthday: sample sizes, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1963-65

Sex and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In millimeters									
Boys												
6-11 years------	48	141	19.9	4.88	1.01	12.5	13.0	17.0	20.0	23.0	26.0	28.0
6 years---------------	-	-	-	-	-	-	-	-	-	-	-	-
7 years---------------	-	-	-	-	-	-	-	-	-	-	-	-
8 years---------------	2	8	*	*	*	*	*	*	*	*	*	*
9 years---------------	3	7	*	*	*	*	*	*	*	*	*	*
10 years--------------	9	27	20.4	2.60	1.42	16.0	16.0	20.0	20.0	21.0	24.0	25.0
11 years--------------	34	98	19.4	5.02	1.10	11.0	13.0	16.5	19.0	22.0	24.0	26.0
Girls												
6-11 years------	64	199	19.1	5.00	0.83	10.0	13.0	15.0	20.0	23.0	26.0	27.0
6 years---------------	-	-	-	-	-	-	-	-	-	-	-	-
7 years---------------	-	-	-	-	-	-	-	-	-	-	-	-
8 years---------------	1	2	*	*	*	*	*	*	*	*	*	*
9 years---------------	6	14	23.7	2.03	1.38	20.0	20.0	22.0	24.5	25.0	26.0	26.0
10 years--------------	19	59	21.8	4.51	1.04	14.0	15.0	19.0	20.0	27.0	27.0	28.0
11 years--------------	38	123	17.2	4.50	0.97	9.0	12.0	14.0	17.0	21.0	24.0	24.5

NOTE: n = sample size; N = estimated number of children in population in thousands; $\bar{X}$ = mean; s = standard deviation; $s_{\bar{x}}$ = standard error of the mean.

Table 19. Triceps skinfold of children aged 6-11 years weighing between 55-59.9 kilograms, by sex and age at last birthday: sample sizes, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1963-65

Sex and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile 5th	10th	25th	50th	75th	90th	95th
			In millimeters									
Boys												
6-11 years	22	65	22.8	4.01	1.02	16.0	18.0	20.0	24.0	25.0	28.0	29.0
6 years	-	-	-	-	-	-	-	-	-	-	-	-
7 years	-	-	-	-	-	-	-	-	-	-	-	-
8 years	-	-	-	-	-	-	-	-	-	-	-	-
9 years	5	21	23.9	3.75	7.89	18.0	18.0	20.0	25.0	26.5	29.0	29.0
10 years	5	15	22.0	2.22	1.35	20.0	20.0	20.0	22.0	24.0	26.0	26.0
11 years	12	29	22.3	4.66	1.93	15.0	16.0	19.5	24.0	25.0	28.0	31.0
Girls												
6-11 years	26	89	19.7	6.68	1.46	12.0	12.0	17.0	22.0	24.0	26.0	28.0
6 years	-	-	-	-	-	-	-	-	-	-	-	-
7 years	-	-	-	-	-	-	-	-	-	-	-	-
8 years	-	-	-	-	-	-	-	-	-	-	-	-
9 years	1	3	*	*	*	*	*	*	*	*	*	*
10 years	4	13	*	*	*	*	*	*	*	*	*	*
11 years	21	73	19.3	7.12	1.59	12.0	12.0	12.0	22.0	25.0	26.0	26.0

NOTE: n = sample size; N = estimated number of children in population in thousands; $\bar{X}$ = mean; s = standard deviation; $s_{\bar{x}}$ = standard error of the mean.

Table 20. Triceps skinfold of children aged 6-11 years weighing between 60-64.9 kilograms, by sex and age at last birthday: sample sizes, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1963-65

Sex and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In millimeters									
Boys												
6-11 years	11	31	24.9	3.23	1.46	22.0	22.0	23.0	25.0	28.0	28.0	29.0
6 years	-	-	-	-	-	-	-	-	-	-	-	-
7 years	-	-	-	-	-	-	-	-	-	-	-	-
8 years	-	-	-	-	-	-	-	-	-	-	-	-
9 years	3	9	*	*	*	*	*	*	*	*	*	*
10 years	2	7	*	*	*	*	*	*	*	*	*	*
11 years	6	15	23.4	3.06	1.27	15.0	15.0	23.0	23.0	25.0	26.0	26.0
Girls												
6-11 years	16	53	23.1	4.85	1.44	15.0	17.0	20.0	22.0	28.0	30.0	31.0
6 years	-	-	-	-	-	-	-	-	-	-	-	-
7 years	-	-	-	-	-	-	-	-	-	-	-	-
8 years	-	-	-	-	-	-	-	-	-	-	-	-
9 years	1	3	*	*	*	*	*	*	*	*	*	*
10 years	3	9	*	*	*	*	*	*	*	*	*	*
11 years	12	41	22.9	4.60	1.75	15.0	17.0	20.0	22.0	28.0	29.0	30.0

NOTE: n = sample size; N = estimated number of children in population in thousands; $\bar{X}$ = mean; s = standard deviation; $s_{\bar{x}}$ = standard error of the mean.

Table 21. Triceps skinfold of children aged 6-11 years weighing between 65-69.9 kilograms, by sex and age at last birthday: sample sizes, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1963-65

Sex and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In millimeters									
Boys												
6-11 years------	8	23	28.2	4.06	6.55	22.5	23.0	24.0	28.0	32.0	34.0	34.0
6 years---------------	-	-	-	-	-	-	-	-	-	-	-	-
7 years---------------	-	-	-	-	-	-	-	-	-	-	-	-
8 years---------------	-	-	-	-	-	-	-	-	-	-	-	-
9 years---------------	2	6	*	*	*	*	*	*	*	*	*	*
10 years--------------	1	3	*	*	*	*	*	*	*	*	*	*
11 years--------------	5	14	27.4	3.82	6.46	22.5	22.5	23.0	30.0	30.0	32.0	32.0
Girls												
6-11 years------	5	16	20.0	4.49	6.72	13.0	13.0	17.0	20.0	24.0	26.0	26.0
6 years---------------	-	-	-	-	-	-	-	-	-	-	-	-
7 years---------------	-	-	-	-	-	-	-	-	-	-	-	-
8 years---------------	-	-	-	-	-	-	-	-	-	-	-	-
9 years---------------	-	-	-	-	-	-	-	-	-	-	-	-
10 years--------------	-	-	-	-	-	-	-	-	-	-	-	-
11 years--------------	5	16	20.0	4.49	6.72	13.0	13.0	17.0	20.0	24.0	26.0	26.0

NOTE: n = sample size; N = estimated number of children in population in thousands; $\bar{X}$ = mean; s = standard deviation; $s_{\bar{x}}$ = standard error of the mean.

Table 22. Triceps skinfold of children aged 6-11 years weighing 70 kilograms or more, by sex and age at last birthday: sample sizes, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1963-65

Sex and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In millimeters									
Boys												
6-11 years	4	11	*	*	*	*	*	*	*	*	*	*
6 years	-	-	-	-	-	-	-	-	-	-	-	-
7 years	-	-	-	-	-	-	-	-	-	-	-	-
8 years	-	-	-	-	-	-	-	-	-	-	-	-
9 years	-	-	-	-	-	-	-	-	-	-	-	-
10 years	1	3	*	*	*	*	*	*	*	*	*	*
11 years	3	8	*	*	*	*	*	*	*	*	*	*
Girls												
6-11 years	6	21	*	*	*	*	*	*	*	*	*	*
6 years	-	-	-	-	-	-	-	-	-	-	-	-
7 years	-	-	-	-	-	-	-	-	-	-	-	-
8 years	-	-	-	-	-	-	-	-	-	-	-	-
9 years	-	-	-	-	-	-	-	-	-	-	-	-
10 years	3	12	*	*	*	*	*	*	*	*	*	*
11 years	3	9	*	*	*	*	*	*	*	*	*	*

NOTE: n = sample size; N= estimated number of children in population in thousands; $\bar{X}$ = mean; s = standard deviation; $s_{\bar{x}}$ = standard error of the mean.

Table 23. Correlations between the triceps and subscapular skinfolds of the Health Examination Survey children and of English children, by race, sex, and age at last birthday

Age	Health Examination Survey children				English children[1]	
	White		Negro		Boys	Girls
	Boys	Girls	Boys	Girls		
6 years	.73	.74	.80	.76	.60	.67
7 years	.80	.63	.73	.87	.65	.71
8 years	.78	.82	.80	.87	.75	.74
9 years	.84	.74	.84	.85	.75	.78
10 years	.80	.82	.80	.79	.78	.76
11 years	.82	.81	.76	.85	.80	.80

[1]SOURCE: Scott.[18] Differential breakdowns by race not available.

APPENDIX I
STATISTICAL NOTES

The Survey Design

The sampling plan of the second cycle of the HES followed a highly stratified, multistage probability design in which a sample of the U.S. population (including Alaska and Hawaii) from the ages of 6 through 11 years inclusive was selected. Excluded were those children confined to an institution or residing upon any of the reservation lands set up for the American Indians.

In the first stage of this design, the nearly 2,000 primary sampling units (PSU's), geographic units into which the United States was divided, were grouped into 357 strata for the use of the Health Interview Survey and the Current Population Survey of the U.S. Bureau of the Census and were then further grouped into 40 superstrata for use in Cycle II of the HES.

The average size of each Cycle II stratum was 4.5 million persons, and all strata fell between the limits of 3.5 and 5.5 million. Grouping into 40 strata was done in a way that maximized homogeneity of the PSU's included in each stratum, particularly with regard to the degree of urbanization, geographic proximity, and degree of industrialization. The 40 strata were classified into four broad geographic regions (each with 10 strata) of approximately equal population and cross-classified into four broad population density groups (each having 10 strata). Each of the resultant 16 cells contained either two or three strata. A single stratum might include only one PSU (or only part of a PSU as, for example, New York City, which represented two strata) or several score PSU's.

To take account of the possible effect that the rate of population change between the 1950 and the 1960 Census might have had on health, the 10 strata within each region were further classified into four classes ranging from those with no increase to those with the greatest relative increase. Each such class contained two or three strata.

One PSU was then selected from each of the 40 strata. A controlled selection technique was used in which the probability of selection of a particular PSU was proportional to its 1960 population. In the controlled selection an attempt was also made to maximize the spread of the PSU's among the States. While not every one of the 64 cells in the 4x4x4 grid contributes a PSU to the sample of 40 PSU's, the controlled selection technique ensured the sample's matching the marginal distributions in all three dimensions and being closely representative of all cross-classifications.

Generally, within a particular PSU, 20 ED's (census enumeration districts) were selected with the probability of selection of a particular ED proportional to its population in the age groups 5-9 years in the 1960 Census, which by 1963 roughly approximated the population in the target age group for Cycle II. A similar method was used for selecting one segment (clusters of households) in each ED. Each of the resultant 20 segments was either a bounded area or a cluster of households (or addresses). All of the children in the age range properly resident at the address visited were EC (eligible children). Operational considerations made it necessary to reduce the number of prospective examinees at any one location to a maximum of 200. The EC to be excluded for this reason from the SC (sample child) group was determined by systematic subsampling. If one of the sample children had a twin who was not a sample child, this other twin was brought in for examination, and while the results were recorded for use in a special substudy of twins, this twin was not included in the 7,119 children under the present analysis.

The total sample included 7,417 children 6-11 years of age of whom 96 percent were finally examined. These 7,119 examined children represented the roughly 24 million children in the United States who met the general criteria for inclusion in the sampling universe as of mid-1964.

All data presented in this publication are based on "weighted" observations. That is, data recorded for each sample child are inflated in the estimation process to characterize the larger universe of which the sample child is representative. The weights used in this inflation process are a product of the reciprocal of the probability of selecting the child, an adjustment for nonresponse cases, and a poststratified ratio adjustment which increases precision by bringing survey results into closer alignment with known U.S. population figures by color and sex for single years of age 6-11.

In the second cycle of the HES the sample was the result of three stages of selection—the single PSU from each stratum, the 20 segments from each sample PSU, and the sample children from the eligible children. The probability of selecting an individual child is the product of the probabilities of selection at each stage.

Since the strata are roughly equal in population size and a nearly equal number of sample children were examined in each of the sample PSU's, the sample design is essentially self-weighting with respect to the target population; that is, each child 6-11 years old had about the same probability of being drawn into the sample.

The adjustment upward for nonresponse is intended to minimize the impact of nonresponse on final estimates by imputing to nonrespondents the characteristics of "similar" respondents. Here "similar" respondents were judged to be examined children in a sample PSU having the same age (in years) and sex as children not examined in that sample PSU.

The poststratified ratio adjustment used in the second cycle achieved most of the gains in precision which would have been attained if the sample had been drawn from a population stratified by age, color, and sex and made the final sample estimates of population agree exactly with independent controls prepared by the U.S. Bureau of the Census for the noninstitutional population of the United States as of August 1, 1964 (approximate midsurvey point) by color and sex for each single year of age 6-11. The weights of every responding sample child in each of the 24 age, color, and sex classes are adjusted upward or downward so that the weighted total within the class equals the independent population control.

A more detailed description of the sampling plan and estimation procedures is included in earlier reports of the *Vital and Health Statistics* series.[4, 5] Series 11, No. 1[4] describes the techniques used in Cycle I, which are similar to those of Cycle II.

Parameter and Variance Estimation

As each of the 7,119 sample children has an assigned statistical weight, all estimates of population parameters presented in HES publications are computed taking this weight into consideration. Thus, $\overline{X}$, the estimate of a population mean, "μ," is computed as follows: $\overline{X}=\sum_{i=1}^{n} W_i \; X_i / \sum W_i$, where X_i is the observation or measurement taken on the i^{th} person and W_i is the statistical weight assigned to that person.

The HES has an extremely complex sampling plan, and obviously the estimation procedure is, by the very nature of the sample, complex as well. A method is required for estimating the reliability of findings which "reflects both the losses from clustering sample cases at two stages and the gains from stratification, ratio estimation, and poststratification."[25]

The method for estimating variances in the HES is the half-sample replication technique. The method was developed at the U.S. Bureau of the Census prior to 1957 and has at times been given limited use in the estimation of the reliability of results from the Current Population Survey. This half-sample replication technique is particularly well suited to the HES because the sample, although complex in design, is relatively small (7,119 cases) and is based on but 40 strata. This feature permitted the development of a variance estimation computer program which produces tables containing desired estimates of aggregates, means, or distributions, together with a table identical in format but with the estimated variances instead of the estimated statistics. The computations required by the method are simple, and the internal storage requirements are well within the limitation of the IBM 360-50 computer system utilized at the National Center for Health Statistics.

Variance estimates computed for this report were based on 20 balanced half-sample replications. A half sample was formed by choosing one sample PSU from each of 20 pairs of sample PSU's. The composition of the 20 half samples was determined by an orthogonal plan. To compute the variance of any statistic, this statistic is computed for each of the 20 half samples. Using the mean as an example, this is denoted $\overline{X}_i$. Then, the weighted mean of the entire, undivided sample ($\overline{\overline{X}}$) is computed. The variance of the mean is the mean square deviation of each of the 20 half-sample means about the overall mean. Symbolically,

$$Var.(\overline{X}) = \frac{\sum_{i=1}^{20}\left(\overline{X}-\overline{\overline{X}}\right)^2}{20}$$

and the standard error of the mean is the square root of this. In a similar manner, the standard error of any statistic may be computed.

A detailed description of this replication process by Philip J. McCarthy, Ph.D., has been published.[25]

Standards of Reliability and Precision

All means, variances, and percentages appearing in this report met defined standards before they were considered acceptably precise and reliable.

The rule for reporting means and percentiles consisted of two basic criteria. The first criterion was that a sample size of at least five was required. If this first criterion was met, then the second criterion, that the coefficient of variation [i.e., the standard error of the mean divided by the mean $(s_{\overline{x}}/\overline{X})$] was to be less than 25 percent, must have been demonstrated. Thus, if either the sample size was too small, or the variation with respect to the mean was too large, the estimate was considered neither precise nor reliable

NOTE: The list of references follows the text.

enough to meet the standards established for publication.

Hypothesis Testing

Although this report on skinfolds is primarily descriptive, it is often desirable to make statistical comparisons between two groups such as males and females or 6-year-olds and 7-year-olds. Classically, if a statistician wishes to test the difference between two means (or, put differently, to test whether two samples could have been drawn from the same population), he could do so by setting up a normal deviate in which he would utilize the means and standard errors of the means as computed from the samples. The statistic

$$z = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{s^2_{\bar{x}_1} + s^2_{\bar{x}_2}}}$$

is then compared to a table of normal deviates to determine whether or not there is, in fact, a difference between the two groups. (Note that the above makes the assumption that the two groups are independent and that $s^2_{\bar{x}} \longrightarrow \sigma^2_{\bar{x}}$.)

While the technique may appeal to many, in the analyses of this report this technique is not used for two basic reasons:

(1) Use of the z statistic makes necessary the assumption of normality. As is clearly shown by the percentile distributions of the variables considered in this report, this assumption is badly violated.

(2) Because of the many breakdowns of the HES sample, innumerable tests of this nature could be performed and, with each new test, the probability of rejecting a hypothesis incorrectly may be .05, but if such tests are performed, the probability of making at least one mistake somewhere in those 10 tests is something closer to .50.

It was therefore decided to place the greatest emphasis on a relationship remaining consistent over both sexes (or races) and all ages under consideration. In other words, to say that "girls have median triceps skinfolds greater than boys for all ages between 6 and 11 years" has far more meaning and interpretability than to say "the mean triceps skinfold for 6-year-old girls is significantly greater than the corresponding mean for 6-year-old boys, and the mean ... for 7-year-old girls is significantly greater than the mean for 7-year-old boys, 8-year-old girls, etc.," as determined by a normal deviate. In these analyses, *consistency* rather than a statement about a succession of individual probability levels is the factor considered most important in demonstrating a relationship.

Analysis of Correlations Among Skinfolds

For each of the 7,119 children in the sample three skinfolds were recorded. The correlation coefficients were computed for each of the three possible pairs of these three skinfold measurements in the following manner:

$$r = \frac{\Sigma w_i \ \Sigma w_i \ X_i Y_i - \Sigma w_i \ X_i (\Sigma w_i \ Y_i)}{\sqrt{[\Sigma w_i \ \Sigma w_i \ X_i^2 - (\Sigma w_i \ X_i)^2][\Sigma w_i \ \Sigma w_i \ Y_i^2 - (\Sigma w_i Y_i)^2]}}$$

where w_i is the weight assigned to the i^{th} individual and X and Y are the two skinfold measurements being correlated.

Three correlation coefficients were computed for each of the 24 age-sex-race categories. The results are presented in table 10. As described in the text, it was decided to rank, within each age-sex-race group, the three correlation coefficients under consideration. The distribution of these ranks is shown in table I.

Note that if each of the pairs was correlated equally, it would be expected that the average rank in each column would be "2," so that the sum of the ranks in each column would be 48. The greater the deviation from 48, the more significant is the difference between pairs of correlation coefficients. It is evident from the above table that the highest ranks were assigned to the two trunk skinfolds (i.e., subscapular and midaxillary), indicating the highest degree of association of all possible pairs, while the ranks were smallest for the triceps-midaxillary correlation, indicating the weakest relationship.

A procedure was sought which would enable a probability level to be assigned to the ranks presented above to further support the initial observations such as a standard nonparametric procedure. Freedman's chi square was not used because the correlation coefficients for the various pairs of skinfolds are not independent. Thus, an alternative procedure was sought which required no assumption of independence. The W_n statistic described in "Some Aspects of the Statistical Analyses of the 'Mixed Model'" by Gary G. Koch and Pranab Kumar Sen, which appeared in *Biometrics*, March 1968, is particularly appropriate here and is based on the ranks described above.

This procedure yields a W_n equal to 13.10 with 2 degrees of freedom when it is applied to this data. Since W_n is distributed as chi square, it can be said with 99 percent confidence that there is a significant difference in correlation coefficients computed from the various combinations of skinfolds.

Table I. Distribution of ranks of correlation coefficients for pairs of skinfold measurements, by race, sex, and age

Race, sex, and age	Skinfold pair		
	Triceps-subscapular	Triceps-midaxillary	Subscapular-midaxillary
WHITE			
Boys			
6 years	2	1	3
7 years	3	2	1
8 years	2	1	3
9 years	2	1	3
10 years	2	1	3
11 years	2	1	3
Girls			
6 years	2	1	3
7 years	2	1	3
8 years	3	1	2
9 years	2	3	1
10 years	3	1	2
11 years	2	1	3
NEGRO			
Boys			
6 years	3	1	2
7 years	1	2	3
8 years	2	1	3
9 years	2	1	3
10 years	2	1	3
11 years	1	2	3
Girls			
6 years	2	1	3
7 years	2	1	3
8 years	2	1	3
9 years	2	1	3
10 years	2	3	1
11 years	1	2	3
Total	49	32	63

APPENDIX II

DEMOGRAPHIC VARIABLES

Regional and demographic characteristics by which the population has been classified for this report are defined as follows.

Age and Sex

Population was classified into 12 age-sex groups—the six ages 6-11 years by sex. For 95 percent of the children the given age was verified by birth certificates. Age stated by the parents was accepted as the true age for the other 5 percent. Age is expressed as years attained at last birthday.

Race

Skinfolds were reported by race for white and Negro children. Children of other races were not sampled sufficiently for comparison purposes; these children represented only 0.45 percent of the sample.

Region

Regional data are presented for four regions of the continental United States.

Region	*States Included*
Northeast	Maine, Vermont, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, Pennsylvania, New Jersey.
Midwest	Minnesota, Wisconsin, Michigan, Iowa, Missouri, Illinois, Indiana, Ohio
South	Delaware, Maryland, Virginia, District of Columbia, West Virginia, Kentucky, Tennessee, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Arkansas, Louisiana
West	Washington, Oregon, Idaho, Montana, North Dakota, South Dakota, Wyoming, Nebraska, Kansas, Colorado, Utah, Nevada, California, Arizona, New Mexico, Texas, Oklahoma

APPENDIX III

TECHNIQUES OF MEASUREMENT AND QUALITY CONTROL

Introduction

In normal, healthy, and well-nourished individuals, as much as 25 percent of the total mass of the body can consist of fat cells in quantities large enough to form a definite adipose tissue. Although a significant proportion of this fat is located internally, often surrounding organs such as the kidney, more than half of it is found subcutaneously where it "blankets" the individual. In a number of regions of the body the adipose layer may be " lifted" with the fingers, i.e., pulled away from underlying tissues, to form a skinfold. The skinfold therefore consists of a *double layer of subcutaneous fat and skin* whose thickness may be measured with appropriate equipment and by exercising reasonable care (figure I).

The major methodological concerns involved in the measurement of skinfold thickness are:

• *The calipers utilized.* There are a number of calipers now available which give comparable results. Figure II illustrates the Lange caliper, now manufactured by Cambridge (Maryland) Scientific Industries, Inc., and used in the Health Examination Survey. As with all acceptable calipers, it is spring-loaded to the closed position and compresses the fold with a constant pressure of 10 grams/mm.[2] throughout its range of openings. The calipers are readily calibrated using a standard aluminum step wedge with widths in increments of 10 mm. If the needle indicator strays even slightly from the exact mark, it can be realigned very easily. Extensive data available at Cambridge Scientific Industries demonstrate that the spring loading is vir-

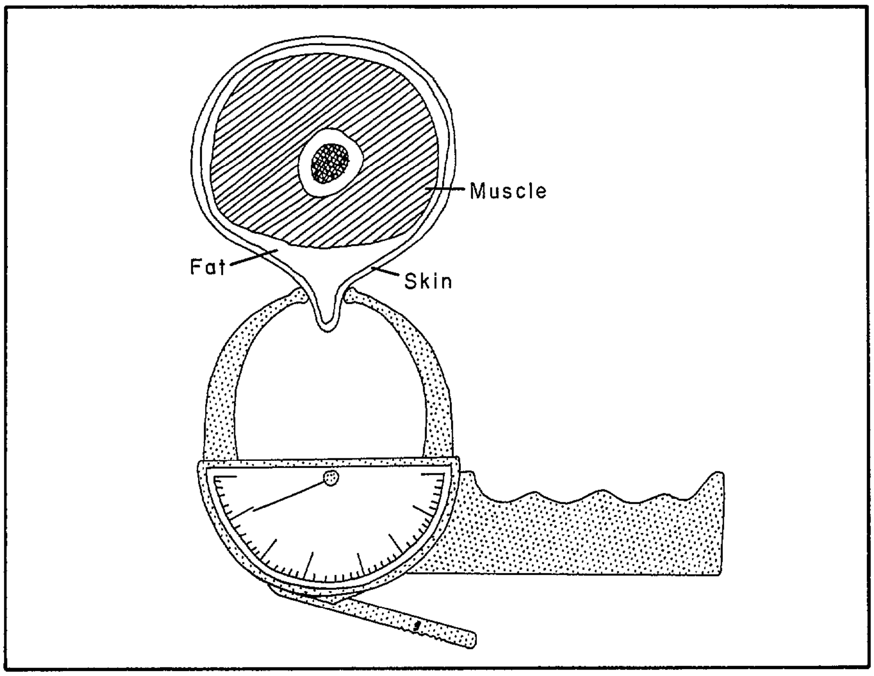

Figure I. Diagram of the technique for measuring a skinfold, a double layer of subcutaneous fat and skin. In this case, the triceps skinfold is being measured with the Lange caliper. (Drawing courtesy of Muriel Kirkpatrick, Dept. of Anthropology, Temple University)

Figure II. Lange caliper.

tually constant and that occasional slight indicator fluctuation is the only drift in the instrument; when the needle is realigned, the measurement becomes precise again.

• *The technique utilized.* The most comprehensive description of the actual technique is given by Brožek [h] as follows (see figure I):

> The "skin" should be lifted by grasping firmly the fold between the thumb and the forefinger. A firm grip, not exceeding the pain threshold, eliminates or at least substantially reduces the variations in the apparent thickness of skinfold that would result from wide differences in the pulling force of the fingers.
>
> The width of the skin that is enclosed between the fingers is an important factor. It cannot be standardized, in its absolute size, for all the sites of the body. With a thick subcutaneous layer a wider segment of the skin must be "pinched" in order to form a fold than when the adipose tissue is poorly developed, as it is on the dorsum of the hand. For a given site the width of the skin should be minimal, still yielding a well defined fold.
>
> The depth of the skinfold at which the calipers are placed on the fold also requires comment. The two sides of the fold are not likely to be parallel, when the skin is lifted by one hand, being narrower near the crest and larger toward the base. When the calipers are placed at the base, the resulting measurement is too large. Here, again, the correct *distance from the crest is defined as the minimal distance from the crest at which a true fold, with surfaces approximately parallel to each other and to the contact surfaces of the calipers, is obtained upon the application of the calipers to the skin.*

[h]From Brožek, J., The measurement of body composition, in M. F. A. Montagu, ed., *An Introduction to Physical Anthropology*, ed. 3, 1960, pp. 637-686. Courtesy of Charles C. Thomas, Publisher, Springfield, Illinois.

Some caliper models only approximate but do not actually achieve the parallelism of the contact surfaces. However, such parallelism is a desirable feature of the calipers. In very obese individuals at some sites no true skinfolds, as defined above, can be obtained. The measurements are still useful as indicators of fatness but the "skinfold" measurements are then larger than a double value of skin plus the subcutaneous layer, taking into account the compression of the tissues by the calipers. It is recommended to lift the skinfold at a distance of about 1 cm. from the site at which the calipers are to be placed and the skinfold measured.

•*The site selected for measurement.* The thickness of the subcutaneous tissue may be measured at any number of sites, and the choice of a site is dictated largely by the problem under investigation. At the same time, certain sites have become more or less standardized as locations which are readily accessible, which may be more accurately measured, which have a layer of fat of relatively uniform thickness, and which serve as a reasonable sample of all the subcutaneous fat of the body. For Cycle II three sites were selected: (1) *triceps,* over the triceps muscle halfway between the elbow and the acromial process of the scapula, with the skinfold parallel to the longitudinal axis of the upper arm; (2) *subscapular,* 1 cm. below the inferior angle of the scapula in line with the natural cleavage lines of the skin; and (3) *midaxillary,* in the midaxillary line, but with the fold perpendicular to it, midway between the nipple and the umbilicus.

HES Measuring Technique

Trained observers measured all skinfolds to the nearest 0.5 mm. The values were read aloud to a recorder, also a trained measurer, who repeated aloud each number back to the observer as it was recorded in the proper space on the record form. This repetition served both as a doublecheck to the measuring technician and to reduce the recorder's errors. The measurement was repeated, and if it did not coincide with the first one, a third one was taken.

All skinfolds and body measurements were performed in a regular sequence to minimize the number of position changes the child was required to make. The sequence is illustrated on the measurement recording form (figure III).

All of the individuals performing body measurements in the HES were experienced X-ray technicians who had been trained in anatomy and the identification of specific body landmarks. In addition, X-ray technicians tend to work well with people and are skilled in giving the examinee verbal orders along with the necessary handling to achieve proper positioning.

Each technician received more than a month of intensive training before being considered proficient in making body measurements. In this training, he became skilled with the equipment, the precise locations of the body at which the measurements were to be taken, and the technique of measurement itself. The major sources of measurement error by the trainee were improper positioning of subject's body, improper selection of specific body landmarks, and improper technique in applying the calipers. Incorrect reading from the instrument (usually transposition of numbers) also occurred. The measurements of each technician were carefully compared with those of the other three and with the measurements of the two supervisors (Dr. Peter V. V. Hamill, the medical advisor, and Dr. Francis E. Johnston, the anthropologic consultant) before they were officially accepted as recordable data.

Broadly conceived, training and quality control have two major goals—(1) to substantially reduce the variability introduced by errors of measurement and (2) to assess the magnitude of the remaining residual error. The achievement of the first goal requires not only suitable initial training but also a persistent ongoing system of quality control. Achieving the second requires the construction of experiments designed to quantify specific components of the error of measurement.

Training and quality control for taking body measurements consisted of seven identifiable procedures, some emphasizing the training component and some the assessment of quality in Cycles II and III:[i]

(1) Careful training of the examiners.

(2) Periodic direct observation by the medical advisor and the anthropologic consultant as measurements were being taken with correction of errors when necessary.

(3) Practice and retraining during dry runs. The first day at each location (that is, approximately one day a month) was devoted to dry runs, during which all equipment was retested and recalibrated and regular practice procedures were carried out. Each technician and either a supervising technician or the supervisors measured one or more people several times. Discrepancies in measurements were discussed and any steps necessary to improve the techniques were taken. Although these were primarily training sessions, they afforded an ongoing informal assessment as to the quality of the data.

---

[i]As a careful and thoughtful quality control program tends to be an evolving process, the most extensive and systematic monitoring for body measurements performed in any of the cycles thus far in the HES was performed in Cycle III (youths 12-17 years, data collection 1966-70). This formal system of replicate examinations which was instituted in Cycle III is referred to in item 7, below, and is described in detail on page 57 of this discussion along with an argument for the validity of applying Cycle III experience to Cycle II.

HEALTH EXAMINATION SURVEY—II

BODY MEASUREMENTS

GPO: 1964—741079

OBSERVER (6-7) | RECORDER

CARD 06 COL. NO.	SITTING *	
8-10	FOOT LENGTH	___ ___.___
11-13	FOOT BREADTH	___ ___.___
14-17	KNEE HEIGHT	___ ___ ___.___
18-21	POPLITEAL HEIGHT	___ ___ ___.___
22-25	THIGH CLEARANCE	___ ___ ___.___
26-28	SEAT BREADTH	___ ___.___
29-31	ELBOW—ELBOW BREADTH	___ ___.___
32-35	SITTING HEIGHT—ERECT	___ ___ ___.___
36-38	BUTTOCK-POPLIT LENGTH	___ ___.___
39-41	BUTTOCK-KNEE LENGTH	___ ___.___
42-44	ELBOW-WRIST LENGTH	___ ___.___
45-47	HAND LENGTH	___ ___.___
48-50	HAND BREADTH	___ ___.___
	STANDING (ON STEP) *	
51-53	R. BICONDYLAR DIAM.	___ ___.___
54-56	R. CALF GIRTH	___ ___.___
57-60	STANDING HEIGHT	___ ___ ___.___
	ANTHRO. NO.	
61-62	COLS. 14-25	___ ___
63-64	COLS. 32-35	___ ___
79-80	END CARD 06	

CARD 07 COL. NO.	STANDING (FLOOR) *	
8-10	BIACROMIAL DIAM.	___ ___.___
11-13	ACROMION TO OLECRANON	___ ___.___
14-16	CHEST BREADTH 4TH ICS	___ ___.___
17-19	CHEST DEPTH 4TH ICS	___ ___.___
20-22	BICRISTAL DIAM.	___ ___.___
23-25	CHEST GIRTH	___ ___.___
26-28	WAIST GIRTH	___ ___.___
29-31	HIP GIRTH	___ ___.___
32-34	R. UPPER ARM GIRTH	___ ___.___
35-37	R. LOWER ARM GIRTH	___ ___.___
	SKIN FOLDS	
38-40	R. UPPER ARM (MM)	___ ___.___
41-43	R. INFRASCAPULAR (MM)	___ ___.___
44-46	R. LAT. CHEST WALL (MM)	___ ___.___
47-50	WEIGHT (LBS)	___ ___ ___.___
79-80	END CARD 07	

* In cm

MEASUREMENTS NOT DONE OR SIDE VARIED—specify which and give reason ....

PHS-4611-3
REV. 7-64

SAMPLE NO. (1-5)

Figure III. Body measurement recording form.

(4) Approximately every 6 to 9 months an intensive evaluation of measurement technique was conducted by the supervisors. These sessions lasted 2 days and involved the measurement, each time, of two boys. One boy was quite fat and the other was linear in physique. On the first day both boys were measured by each of the four technicians with the supervisors acting as recorders. The following day the procedure was repeated, thus giving both inter-observer and intra-observer comparison of sets of measurements. It was only at this time that the technicians were allowed to see the previous measurements and to compare theirs with their own and with the other three sets. Major discrepancies were noted and attempts were made to establish the sources of differences and to eliminate them. In addition, such matters as underlying principles of growth and development and the significance of the survey were discussed.

These sessions were intended to include assessment of errors due to technician differences, to differences in physiques of subjects, to the site of the skinfold, as well as to interactions among these sources of error. For a variety of reasons, e.g., number of subjects and a greater number of technicians in Cycle III than originally specified in the model for the analysis of variance, the assessment was ultimately abandoned.

(5) A daily instrument check was performed on the calipers using the step wedge as described in the section "Calipers Utilized," earlier in this appendix.

Several additional calipers were on hand both to enable the staff to periodically return the instruments to the factory for cleaning and for double-checking their precision and to insure against the loss of data in the event of instrument loss or damage.

(6) In Cycle II, the two Examining Caravans converged from the East and from the West on the Greater Chicago area, at which two stands were conducted (described in reference 5). After the regular examinations had been completed in the normal fashion, and without prior warning, Caravan I reexamined approximately 50 children who had been examined by the staff of Caravan II and vice versa.

(7) The analysis of a set of 301 replicate examinations, taken during 30 stands over the 4 years of Cycle III, provided an estimate of the magnitude of measuring error. These data are the subject of the detailed analysis in the following pages and are judged to provide a fair estimate of the actual residual variable measurement error as it occurred during the Cycle II and Cycle III measurements of skinfolds.

Surveillance and Evaluation of Residual Measurement Process Error

This section is extracted from a recent publication, *Quality Control in a National Health Examination Survey.*[26] This unusually lucid and well-organized report on quality control was written by Wesley Schaible, the quality control officer of the HES. Material within brackets has been added to focus the discussion on skinfold measurements.

Monitoring Systems

Despite efforts to reduce measurement errors, residual errors of a magnitude large enough to warrant concern occur with some regularity [in any anthropometric survey]. There is, therefore, a real and urgent need to have a system whereby these residual errors can be monitored. The concept of quality control is based on the desire to obtain end products of a certain quality. Thus, one of the main purposes of a monitoring system is to indicate whether the measurements produced by a certain measurement process attain the desired quality. A second purpose is to make possible quantitative summary descriptions of residual measurement errors to aid in the interpretation of survey data.

The most extensive system of monitoring used in the HES in Cycle III was the collection and evaluation of replicate data. Replicate measurements are useful for a variety of purposes—for example, as a means of increasing precision of estimates of individual measurements, as a training technique, and as a monitoring system which includes the objective of final evaluation of measurement errors. These objectives are not incompatible, and replicate data collected primarily for one of these objectives often indirectly, if not directly, accomplish one or both of the remaining two. For this reason replicate data are most often collected with a combination of these objectives in mind. The single most important source of replicate data in Cycle III was the replicate examinations, in which approximately 5 percent of the regular examinees were returned to the examination center for a second complete examination except for drawing blood and taking X-rays.

Biases and Controls in Replicate Measurements

A major source of uncertainty in estimates derived from replicate measurements is in the inability to make the replicate measurement under precisely the same conditions and in the same manner as for the original measurement. This uncertainty is difficult to evaluate and most attempts to do so are restricted to subjective statements concerning the direction and/or size of the bias and the need for concern in the analysis of data.

Several policies regarding Cycle III replicate examinations were specific in the attempt to obtain measurements taken under the same conditions and in the same manner. Replicate examinations were not conducted during a specific time, but whenever possible were interspersed among the regular examinations. An original examination was given priority over a replicate examination in that none was scheduled if it occupied time needed for a regular examination. In practice there was often space to interject replicate examinations in the schedule without interfering with regular examinations. However, this priority plus the fact that replicates were drawn from those examined increased the likelihood that a replicate examination would be scheduled toward the end of the examination period. Nevertheless, the attempt to space the replicate examinations in the schedule was a valuable policy in that the interspacing of replicate and original examinations created an atmosphere more conducive to the replicate examination's being conducted in essentially the same manner as the original.

The examiners had been informed of the purpose and importance of the reexaminations. It was emphasized that they should not vary their procedures on a replicate examination or in any way try to collect "better" data than they normally would. Thereafter, the conduct of a replicate examination was not given any greater

NOTE: The list of references follows the text.

emphasis than any other instruction since overemphasizing "sameness" might have created more bias than it should have eliminated.

At the time of the original examination neither the observer nor the examinee knew whether or not the examinee would be returned for a replicate examination. During the replicate examination, observers were not specifically informed that an examinee was a replicate although no attempt was made to conceal this fact since in an examination as lengthy as that given in HES the examinee would undoubtedly be remembered by several, if not all, examiners. Even though an examinee might be remembered, it was extremely unlikely that an examiner would remember a specific measurement after a time lapse of 2 or 3 weeks. Some bias might be introduced by the examiner's knowledge of the replicate status of an examinee, but generally this bias would seem quite small when compared to the measurement error and in some cases to the biases associated with the knowledge and familiarity gained by the examinee during the original examination. Examinee bias can be important, especially in measurements for which a response is elicited or when the true value of the measurement has changed because of a time lapse. Since the time lapse was usually 2 or 3 weeks, some appreciable changes might occur in certain measurements such as weight. However, for most of the data collected the actual change [over time] can only be very small, so this effect may usually be neglected. [For example, the examinee's previous experience is much more likely to affect, to some extent, the true replicability of the psychological tests and those physiologic tests requiring high levels of subject participation such as the treadmill and spirometry; but on those procedures in which the subject is *passive,* such as EKG and skinfold measurements, with very little learning involved, the effect of the previous experience is almost zero in Cycle III.]

Replicate data were obtained on approximately 70 percent of those selected for such examinations. One explanation for this low rate is that the persuasion and followup efforts were not as intensive as for regular examinees. This is a partial result of giving priority to regular examinees if interviewer or examination time was limited. There also seems to be an increased objection to returning for a second examination, as demonstrated in the most frequent reasons for refusal: "One time is enough" and "I can't miss school again."

Selection of Replicate Examinees

The selection of Cycle III examinees for replicate examinations was random within certain restrictions imposed by practical considerations. One of the restrictions was that replicates were selected only from those examined during the first week and a half of the approximately 3½ weeks of examinations at any one location. This time period was chosen to facilitate the interspersing of replicate examinations with originals in the examining schedule without interfering with the time allotted for original examinations and without scheduling additional time to accommodate replicates. In a voluntary survey it is obviously impossible to follow a statistically random process in scheduling subjects, so those scheduled during the first week and a half are not, in the strict sense, a random sample of all those scheduled, though they may be randomly distributed for those features which are significant. Evidence that replicates might be considered "representative" is found in the fact that youths of certain ages, locations, incomes, etc., are not routinely more likely to be scheduled during any particular segment of the examination schedule. However, the availability and desires of the subjects do influence the composition of the replicate sample. For instance, an examinee whose participation in an original examination was achieved only after repeated contacts by survey personnel is more likely to have been excluded from a replicate examination since it is unlikely that he would have received an original examination during the first week and a half. The schedule of locations considering time of year, sequencing of examinations, relation to other events which might make subjects more or less available, and other related aspects give no obvious discriminatory factor. After examining these and other relatively minor considerations there appears to be no reason to believe that the subjects scheduled and examined during the first part of a stand differ from those scheduled and examined during the latter portion of a stand with respect to the data gathered.

Another restriction on complete randomness in the selection of examinees for replicate examinations was the exclusion of those examinees who were "geographically inconvenient" to the examination center. "Geographically inconvenient" was arbitrarily defined as a distance of 30 miles or greater; although if conditions dictated, exceptions were sometimes allowed. A primary consideration in choosing a site for the examination center was the centrality of the location in relation to the sample segments (a segment is a cluster of households). Since segments were drawn with probability proportional to population, most segments were in relatively populated areas; and so the examination center was also in or adjacent to a relatively populated area. Therefore, the subjects deleted by this 30-mile restriction usually resided in relatively less populated areas; so this restriction may create a bias in the replicate data if, in fact, characteristics and errors of concern differed by population density. Even if differences did exist, the total effect of this restraint was not great since it excluded only approximately 10 percent of the eligible examinees. There were other minor restrictions of medical and operational nature imposed on the complete randomness of the replicate sample, but they were not readily associated with large differences. Also they deleted at most only 1-2 percent of the eligible examinees and for these reasons are of small consequence.

Since the purpose of replicate examinations is to give information about errors, the matter of concern between those excluded and those eligible for selection is not the possible differences in the values of measurements but the possible differences in the errors associated with the measurements as shown by the discrepancy between two measurements on the same subject. It should also be noted that although subjects did influence measurement errors [for some types of examinations], the environment, procedures, and examiners were also highly influential. The consideration of these additional influences causes a completely random selection of subjects to be of somewhat less concern.

(Note: This concludes the material extracted from Schaible's paper.)

Evaluation of Residual Measurement Error in Skinfold Measurements

The residual error of measurement was estimated from a set of 301 replicate examinations conducted, as outlined below, during Cycle III of the HES. There is every reason to believe that this assessment, although derived from studies in the subsequent cycle of examinations (i.e., Cycle III), is valid and completely applicable because the conditions of the body measurement examinations were essentially identical in the two cycles. There were, however, three differences: (1) the children examined during Cycle II were younger and smaller; (2) two skinfolds (median calf and suprailiac) were added in Cycle III, but the location and measuring technique of the other three remained identical; and (3) a total of 11 technicians made measurements during Cycle III, while in Cycle II, the same four technicians participated in equal degrees throughout the entire cycle. Otherwise, the instrument and its calibration, the technique, the training procedures, the selection of technicians (in fact, two of the four technicians from Cycle II continued for several years into Cycle III), the examining environment, and the chief medical advisor and the anthropologic consultant were the same.

There is no reason to suspect that the relative errors of measurement for the Cycle II children differ significantly from those of Cycle III. Thus, the only appreciable differences in quality control considerations for body measurements between Cycles II and III are in the greater number of technicians utilized in Cycle III and its longer duration (4 years compared to 2½ years). These were just about counterbalanced by the more strenuous and more systematic surveillance in Cycle III.

Body measurements were taken on 6,768 youths and these children comprised the HES Cycle III sample. At 30 of the 40 locations (or stands) visited throughout the United States, replicate body measurements were obtained on 301 children. That is, an average of 10 youths were reexamined at each stand. Of the 301 youths, 224 were reexamined by a technician other than the one initially measuring the youth, while the remaining 77 were reexamined by the same technician. All together during the 4 years, 11 technicians participated in replicate measurements for this phase of the quality control program.

Table II presents the percentage of total examinations performed by each technician and the percentages of intra-examiner and inter-examiner replicates in which the 11 technicians were involved.

Table II. Percentage of regular and replicate examinations performed by each technician

Technician number	Percentage of regular Cycle III examinations	Replicate examinations	
		Percentage of intra-examinations	Percentage of inter-examinations
1	0.8	1.3	0.9
2	13.4	2.7	10.2
3	22.8	21.3	21.4
4	6.1	4.0	2.7
5	13.5	10.7	16.7
6	6.1	5.3	6.5
7	3.7	5.3	4.9
8	15.1	24.0	16.4
9	11.3	16.0	13.3
10	3.0	2.7	3.6
11	4.1	6.7	3.6

The above table indicates some possible sources of bias which may affect the analysis of replicate data. For example, assume technician number 9 was able to replicate his own measurements very well, but his readings were quite different from those of the other examiners. Obviously, his results would be overrepresented in the replicate analysis because he examined only 11.3 percent of all youths in the actual survey, but did 16 percent of the intra-examiner replicate examinations and 13.3 percent of the inter-examiner replicate examinations. Because of this technician's overrepresentation in the replicate study, the distribution of intra-examiner differences would cluster closer to zero than it really should have since this examiner self-replicates well. On the other hand, the inter-examiner distribution of differences would be considerably more skewed than it should have been since this technician does not agree well with the other technicians' measurements. Similar discrepancies are obvious for other technicians. An example of an opposite effect to that cited above is technician number 2, who did only 2.7 percent of the intra-examiner replicate measurements and 10.2 percent of the inter-examiner replicate measurements, but did 13.4 percent of all examinations in Cycle III.

Thus, the various combinations of observers for the inter-examiner replicates and the proportions of intra-examiner replicates were not controlled so as to be balanced among the observers. In the survey proper the examinations were similarly not proportionately distributed among the observers—an imbalance caused by the variation in the length of time the various technicians were associated with the survey.

The foregoing indicates that the distribution of numbers of replicate examinations done by each technician is not the same as the distribution of the total number of survey examinations done by each in Cycle III. This is one of the inherent problems of the present replicate data, and limits to some extent implications to the survey as a whole. Nevertheless, the reader should be aware of the many problems confronting those who conduct large-scale health surveys[26] and in this context, the present systematic approach to the collection of replicate body measurement data is adequate.

Results of Replicate Examinations

The absolute differences between the first and the second examinations were computed for each child on each of the three skinfolds of interest and the results are presented below.

NOTE: The list of references follows the text.

Inter-Examiner Differences

There were 224 youths reexamined by a technician other than the one who did the initial examination. The distributions of absolute differences between the findings of the two examinations are shown in table III.

For each of the three skinfold measurements the modal difference was 0.5 mm., but the triceps skinfold appears to have more large differences than either the subscapular or midaxillary skinfolds; this is reflected in the triceps' larger mean difference (1.89 mm.) as well as its greater median difference (1.5 mm.) as compared with those of the other two. The distributions of subscapular and midaxillary differences have very similar means to each other along with equal medians and modes.

A widely used measure of replicability is the statistic σ_e, the technical error of measurement defined as $\sigma_e = \sqrt{\Sigma d^2/2n}$. This assumes that the distribution of replicate differences is normal and that the errors of all pairs can be pooled. The results of the calculations of this statistic are shown in table III. As expected, the largest value belongs to triceps skinfold with the subscapular and midaxillary sites exhibiting little difference.

Triceps:	1.89
Subscapular:	1.53
Midaxillary:	1.47

This comparison is somewhat misleading since the triceps is the largest of the three skinfold measurements and has the greatest variance (see tables 1-3). On the other hand, the midaxillary and subscapular skinfolds are highly correlated and have similar distributions since both are trunk measurements. By expressing the technical error relative to the appropriate mean, a coefficient of variation (i.e., a measure of *relative* error) is obtained. Thus,

$$\text{coefficient of variation} = \frac{\text{technical error}}{\text{average measurement}} \times 100$$

Since, in Cycle III, the average values for these skinfolds over all ages and sexes were:

Triceps:	12.25
Subscapular:	9.97
Midaxillary:	8.47

the following are the coefficients of variation:

Triceps:	15.44
Subscapular:	15.37
Midaxillary:	17.39

Table III. Distribution of inter-examiner differences between the initial and the replicate examinations for the three skinfolds

Absolute difference, d, in mm.	Difference squared, d^2	Triceps skinfold		Subscapular skinfold		Midaxillary skinfold	
		Frequency[1]	Percent	Frequency[1]	Percent	Frequency[1]	Percent
0.0	0.00	21	9.4	48	21.4	40	17.9
0.5	0.25	52	23.2	61	27.2	64	28.6
[2]0.6	0.00	0	0.0	1	0.4	0	0.0
[2]0.9	0.00	0	0.0	1	0.4	0	0.0
1.0	1.00	37	16.5	42	18.7	43	19.2
1.5	2.25	21	9.4	17	7.6	25	11.2
2.0	4.00	16	7.1	15	6.7	17	7.6
2.5	6.25	22	9.8	11	4.9	9	4.0
3.0	9.00	18	8.0	4	1.8	6	2.7
3.5	12.25	10	4.5	3	1.3	3	1.3
4.0	16.00	11	4.9	6	2.7	3	1.3
4.5	20.25	4	1.8	0	0.0	1	0.4
5.0	25.00	1	0.5	5	2.2	6	2.7
5.5	30.25	2	0.9	3	1.3	1	0.4
6.0	36.00	2	0.9	2	0.9	2	0.9
6.5	42.25	2	0.9	1	0.4	0	0.0
7.0	49.00	2	0.9	0	0.0	0	0.0
7.5	56.25	0	0.0	0	0.0	1	0.4
8.0	64.00	0	0.0	1	0.4	1	0.4
8.5	72.25	0	0.0	1	0.4	0	0.0
9.0	81.00	0	0.0	1	0.4	0	0.0
9.5	90.25	0	0.0	0	0.0	1	0.4
10.5	110.25	0	0.0	1	0.4	1	0.4
11.0	121.00	1	0.5	0	0.0	0	0.0
12.0	144.00	1	0.5	0	0.0	0	0.0
12.5	156.25	1	0.5	0	0.0	0	0.0
Sample size, n		224	100.0	224	100.0	224	100.0
Mean difference, $\bar{d}$, in mm.		1.89		1.34		1.33	
Median in mm.		1.5		1.0		1.0	
Mode in mm.		0.5		0.5		0.5	
Σd^2		1601.5		1051.7		971.5	
$\Sigma d^2/2n$		3.58		2.35		2.17	

[1]Number of replicate examinations exhibiting indicated differences.
[2]Such differences may be caused by failure of technicians to round measurement to nearest half-millimeter or by a miscoding error undetected during imputation.

Viewed in terms of relative error, the triceps no longer appears the most poorly replicated measurement; in fact, the midaxillary now appears the most poorly replicated.

Intra-Examiner Differences

A similar analysis was also conducted for the 77 youths reexamined by the same technician. The distributions of differences are shown in table IV.

Here, the situation is the reverse of the one observed for inter-examiner differences, the triceps measurement having the smallest mean difference of the three, though all have equal medians. The modal difference for the subscapular measurement is zero and 0.5 mm. for both the triceps and midaxillary measurements. The technical error of the triceps measurement is lower than either of the others with the two trunk measurements apparently very similar:

Triceps : 0.80
Subscapular: 1.83
Midaxillary: 2.08

Computation of coefficients of variation accentuates the intra-examiner precision in triceps measurement. The coefficients of variation are as follows:

Triceps: 6.51
Subscapular: 18.33
Midaxillary: 24.51

The triceps measurement obviously has the lowest coefficient of variation of the three skinfold measurements under consideration, while the midaxillary skinfold exhibits the worst replicability of the three.

Table IV. Distribution of intra-examiner differences between the initial and the replicate examinations for the three skinfolds

Absolute difference, d, in mm.	Difference squared, d^2	Triceps skinfold		Subscapular skinfold		Midaxillary skinfold	
		Frequency[1]	Percent	Frequency[1]	Percent	Frequency[1]	Percent
0.0	0.00	21	27.3	29	37.7	24	31.2
0.5	0.25	27	35.1	22	28.6	24	31.2
1.0	1.00	13	16.9	11	14.3	14	18.2
1.5	2.25	7	9.1	4	5.2	4	5.2
2.0	4.00	4	5.2	2	2.6	5	6.5
2.5	6.25	2	2.6	2	2.6	1	1.3
3.0	9.00	2	2.6	2	2.6	1	1.3
3.5	12.25	0	0.0	1	1.3	0	0.0
4.0	16.00	1	1.3	1	1.3	0	0.0
4.5	20.25	0	0.0	0	0.0	1	1.3
5.0	25.00	0	0.0	1	1.3	2	2.6
6.0	36.00	0	0.0	1	1.3	0	0.0
19.0	261.00	0	0.0	1	1.3	0	0.0
23.0	529.00	0	0.0	0	0.0	1	1.3
Sample size, n		77	100.0	77	100.0	77	100.0
Mean difference, $\bar{d}$, in mm.		0.78		1.05		1.10	
Median in mm.		0.5		0.5		0.5	
Mode in mm.		0.5		0.0		0.5	
Σd^2		98.0		514.2		663.5	
$\Sigma d^2/2n$		0.64		3.34		4.31	

[1]Number of replicate examinations exhibiting indicated differences.

Within each skinfold, the significances of differences between the intra- and inter-observer errors of measurement were tested by computing the F ratios of their squares. The results were as follows:

Triceps: 4.20
Subscapular: 1.42
Midaxillary: 1.29

Tests of these at the .01 level (to keep the overall error rate below 5 percent) showed that the triceps is the only skinfold of the three in which the inter- and intra-examiner technical errors differ significantly. That is, agreement was significantly better when the same observer replicated the initial measurement of the triceps. For the other two skinfolds, the error associated with two observers was no greater than the intra-observer error.

These findings indicate that error in skinfold measurement is related to both the site and number of observers utilized. The measurement of the thickness of the triceps skinfold involves more highly individual techniques, probably related to the precise spot over the muscle, the manner in which the fold is "picked up," and the point at which the caliper faces make contact with the skin. In addition, although a formally analyzed study was not conducted, a clinical impression was formed in the training sessions that the precise site chosen for measurement was more critical in the triceps region than in either the subscapular or midaxillary regions (presumably the subcutaneous fat varies in thickness more in the triceps region as one strays from the exact site—i.e., around the circumference of the arm—than in the other two regions). A single observer will become quite consistent in terms of his or her own technique, and self-replication will be quite high.

On the other hand, such individualized techniques are not as important for the two trunk sites since the adipose layer in these regions is thinner and more uniform in thickness than in the arm. The associated error is more likely to be randomized and not to be so strongly affected by "examiner-specific" factors.

Conclusions

From the above, some conclusions may be drawn relative to the error of measurement associated with the HES. The median error for all skinfolds is 1.0 to 1.5 mm. This error, though absolutely small, is relatively quite high in view of the usual thickness of skinfolds encountered. In addition, quite large errors can occur, replicate differences of 12.5 mm. being observed for the triceps and 10.5 mm. for the subscapular and midaxillary folds. These errors remain as residuals despite the careful quality control exercised throughout Cycles II and III. The meaning of such errors may be evaluated only in light of the fact that the measurement of body fat is of considerable biomedical import and, in many cases, skinfolds provide the only estimates available.

With well-trained and supervised observers, the residual errors of measurement are the same for the subscapular skinfolds regardless of whether one or several observers are utilized. Such is not the case for the triceps, however, because the residual is significantly less when only one observer does the measuring. On the other hand, the possibility of systematic errors is greater with only one observer, leading to a potentially systematic bias in the distributions.

In a longitudinal study, a single observer is always preferable. The major purpose of such a design is to determine change in individuals over time. A single observer will provide more consistent readings and therefore a more accurate estimate of change. However, since use of a single observer increases the possibility of systematic bias, the reliability of longitudinal studies is reduced for estimates of the distribution of absolute values in the general population.

In a cross-sectional study, multiple examiners are preferable so far as the subscapular and midaxillary skinfolds are concerned. Not only are residual errors of measurement the same regardless of whether one or several observers are used, but also the systematic bias introduced by use of a single observer will be eliminated.

For cross-sectional studies involving the triceps skinfold, the situation is more complex. If the purpose is to estimate the distribution of the triceps skinfold in a population, multiple examiners will provide better estimates since systematic error will be more likely to be reduced.

If the purpose is to make comparisons of triceps skinfold between groups, then the design of the study, based on considerations of all factors, must reconcile two opposing problems:

(1) Multiple examiners will increase the variability of the distribution because of the inclusion of inter-examiner errors of measurement.

(2) Single-examiner measurements will result in a variance more comparable to the true value for the population. However, since a single observer may measure different kinds of individuals in a systematically different way, new problems of bias may be introduced.

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