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Number 132

Skinfold Thickness of Youths 12-17 Years

United States

Skinfold measurements at five anatomical sites are presented and discussed by age, sex, race, and geographic region of the country for youths 12-17 years of age in the United States, 1966-70.

DHEW Publication No. (HRA) 74-1614

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
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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, Cycle I of the Health Examination Survey. 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 latter reports from Cycles II and III 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.

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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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SKINFOLD THICKNESS OF YOUTHS
12-17 YEARS, UNITED STATES

Francis E. Johnston, Ph.D., Peter V. V. Hamill, M.D., M.P.H., and Stanley Lemeshow, M.S.P.H.[a]

INTRODUCTION

This report presents skinfold measurements of youths 12-17 years of age in the noninstitutionalized population of the United States, as estimated from the Health Examination Survey (HES) of 1966-70. Findings have been analyzed by age, sex, race, and geographic region. Publication of this report completes a series describing and analyzing the quantity and distribution of subcutaneous fat in individuals and groups over the age range of 6-79 years.

The HES was conducted as a series of separate programs, called cycles, each of which examined national probability samples of a specific age range of the noninstitutionalized population of the United States for a variety of information related to health and development.

Cycle I in 1959-62 focused on the prevalence of certain chronic diseases and the distribution of various physical and physiological measures among the adult population, ages 18-79 years, as described previously.[1,2]

During Cycle II in 1963-65, a range of factors were examined in children 6-11 years of age including those related to health, growth, and development.[3]

Cycle III, 1966-70, the program on which the findings in this report are based, was further designed to obtain basic measures of growth and development, as well as data on other health-related characteristics of the adolescent population ages 12-17 years. The survey plan, sample design, examination content, and operation of this survey program have been described in a previous report.[4]

Most of the results of these three cycles are appearing in this series (Series 11) of the *Vital and Health Statistics* reports. Skinfold measurements from Cycle I (adults 18-79 years) were published in Series 11, No. 35;[5] those from Cycle II (children 6-11 years) were published in Series 11, No. 120.[6]

For Cycle III, a national probability sample of 7,514 noninstitutionalized youths 12-17 years of age in the United States was selected. Of this sample, 90 percent were examined. This national sample and the examined group constitute a representative sample of the 22.7 million noninstitutionalized youths 12-17 years in the United States with respect to age, sex, race, and geographic region.

From the standpoint of human growth and development, the adolescent period is one of intense interest and extreme importance. It is during these years that the body structure of the child is transformed into the morphology of the adult. Apart from the secondary sex characteristics, much of the sexual dimorphism observable in adults arises during adolescence and virtually the entire body in some way participates in the phenomenon known as the adolescent spurt, characterized by marked changes in the growth rates and by rapid movement to adulthood.[7] For these reasons the battery of measurements taken in Cycle II was altered and expanded for Cycle III,

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after considerable discussion and consultation, so that the data obtained from Cycle III would reflect the changes in size, shape, and body composition associated with adolescence.

One of the most important features of human development, and one receiving more and more attention, is the composition of the body, i.e., the constituents of its mass, and the changes of these components. While there are many models used to partition mass, from a quantitative aspect, into its component tissues, depending upon the investigator's instrumentation and the problem under consideration, the measurements of the thickness of skinfolds at specific and appropriate sites provide an acceptably accurate and demonstrably meaningful parameter for estimating the degree of fatness of the body.[6] In addition, it is the only approach feasible for epidemiological surveys involving large sample sizes. Finally, it is basic to the evaluation of fatness/leanness in the clinical examination of individual subjects. The use of skinfolds and the integration of these data with those obtained from more complex and involved procedures have been covered in a number of publications, e.g., by Brožek[8] and by Malina.[9]

This report presents the distributions of skinfold thicknesses among youths 12-17 years old at five sites on the body, as measured in Cycle III of the HES, and as related to age, sex, race, and geographic region, along with certain analyses of the differences noted. The format is similar to the report on skinfolds from Cycle II[6] to allow extrapolation and integration, and where appropriate, data from the 6 through 11-year-old sample are included to provide a more comprehensive view of the growing years.

Statistical notes, including survey design, response rates, and reliability of the data, are included in appendix I. Appendix II lists pertinent demographic variables, while appendix III describes measurement techniques and quality control procedures.

METHOD

At each of 40 preselected locations throughout the United States the youths were brought to centrally located mobile examination centers for an examination which lasted about 3 hours. Ideally, six youths were examined in the morning and six in the afternoon.

When the children entered the examination center, their oral temperatures were taken and a cursory screening for acute illness was made; if illness was detected, the youth was sent home and examined later. The examinees changed into shorts, cotton sweat socks, and a light sleeveless topper, 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. At these stations there were examinations by a pediatrician, a dentist, and a psychologist, and at the others highly trained technicians performed a number of other examinations, including X-rays of chest and hand-wrist, hearing and vision tests, respiratory function tests and electrocardiography, an exercise test (treadmill), a battery of body measurements, and a grip strength test.

In Cycle I of the HES two skinfolds were measured. One more was added for Cycle II. The considerations mentioned in the Introduction warranted another increase for the Cycle III examination of youths and consequently two more were added, bringing the total to five skinfolds.

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 to obtain replicate data for the purpose of quantifying observer error. The results of the replicate examinations are presented in appendix III together with a description of the technique of measuring skinfolds.

Each of the skinfolds measured was selected either because data were available from Cycles I and II and/or because each provided a significant piece of information on the dynamics of subcutaneous fat deposition during adolescence. The rationale for selection is described below. Diagrams of the five skinfold sites are shown in figure III in appendix III.

The *triceps skinfold* was measured over the triceps muscle at the midpoint of the upper arm. In addition to it being the site at which skinfold measurements are most frequently taken, it provides information on the quantity of extremity fat and may be a valuable indicator of obesity.[10]

The *subscapular skinfold* was measured just below the inferior angle of the right scapula. It is the next most commonly measured skinfold and it allows an estimate of fat on the trunk. Some studies have suggested that it may be the skinfold which, by itself, is most highly correlated with total body fat.[11]

The *midaxillary skinfold*, taken in the midline as its name implies, and halfway between the nipple and the umbilicus, provides another estimate of trunk fat at a site where the thickness of the adipose layer is minimal.

The *suprailiac skinfold* was added in Cycle III to permit an estimate of subcutaneous fat deposition at what is perhaps the major "depot" of the body where quite marked amounts of fat accumulate in some individuals. The skinfold was picked up over the crest of the ilium inferior to the midaxillary region and measured along a natural line with a front-to-back axis.

The *medial calf skinfold*, also added in Cycle III, was measured to provide information on lower limb fat and to enable one to conclude whether the triceps fold was in fact a valid indicator of both the upper and lower extremities. In a few individuals the skin and underlying tissues were "stretched" so tightly that a satisfactory fold could not be picked up at this site. No measurement was recorded for these subjects; however, they amounted to only 1 percent of the total sample measured.

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 13-year-old male group consists of a 1-year cohort whose mean age is 13.49 years, while the corresponding female sample averages 13.48 years. The ages were validated from birth certificates in 92 percent of the subjects.

"Race" was recorded as "white," "Negro," and "other races." The white youths made up 83.98 percent of the total, the Negro youths 15.71 percent, and youths of "other races" only 0.32 percent. Because so few youths were classified as "other races," data from them were not analyzed separately. These data are included when "total" is used but are dropped when a white/Negro dichotomy is employed.

RESULTS

Age Differences

Tables 1-5 present the basic distributions of the data by age and sex. All of the values were derived from the weighted sample sizes. As discussed in the report of skinfolds from Cycle II,[6] the mean and its standard error are presented mainly for the information of those investigators who continue to use them. However, the marked skewness of all distributions strongly argues for the use of the median (50th percentile) as the best measure of central tendency and for percentiles as measures of variability. These parameters are used in the analyses in this report; the means are used only when special information can be gained from them.

The percentiles are graphed by age and sex for each skinfold in figures 1-5 to permit a visual evaluation of age trends and sex differences.

The skewness described for the Cycle II sample is also quite evident in these figures, the distance from the 50th to the 95th percentile being considerably greater than that from the 5th to the 50th, regardless of the age, sex, or site.

Among girls, there is a general tendency for the medians to increase from one year to the next, indicating a steady accumulation of fat throughout adolescence. However, there are some exceptions to this statement which warrant pointing out. The median midaxillary fold increases through age 16, but the value for 17-year-olds is less. At the suprailiac site, the median skinfold thickness for 16- and for 17-year-olds is less than for the preceding age groups. For the 17-year-old group, the decrease is in the order of the increases noted for earlier years and, in view of the design and

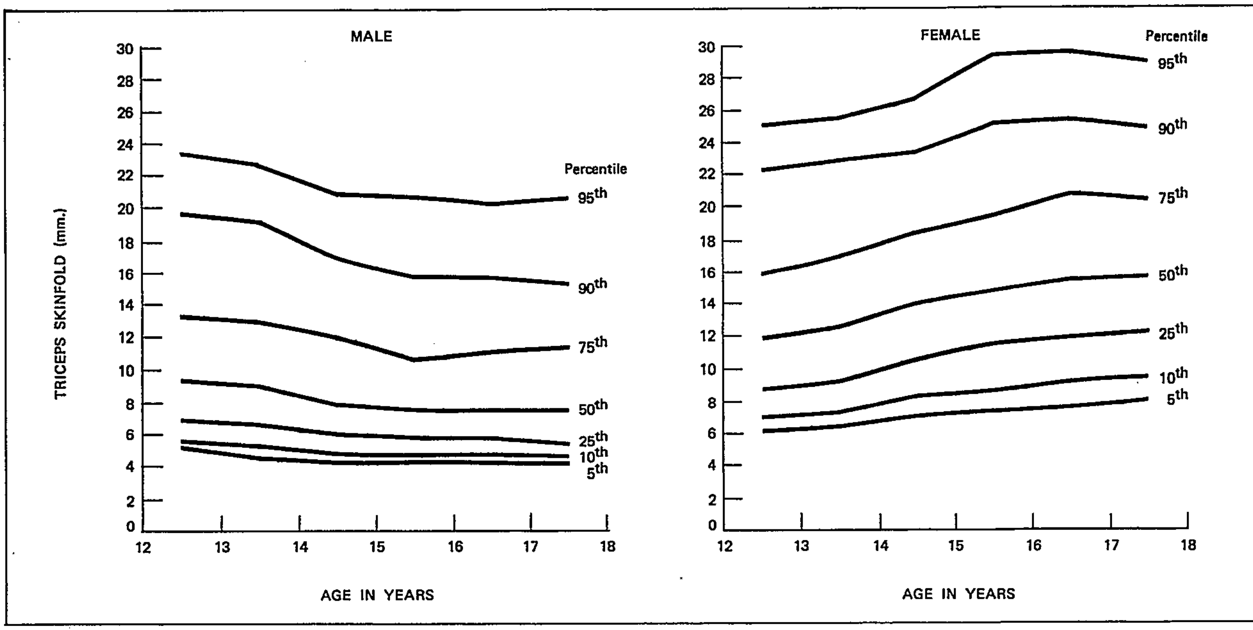


Figure 1. Distributions by selected percentiles of the triceps skinfold of U.S. youths, by age and sex.

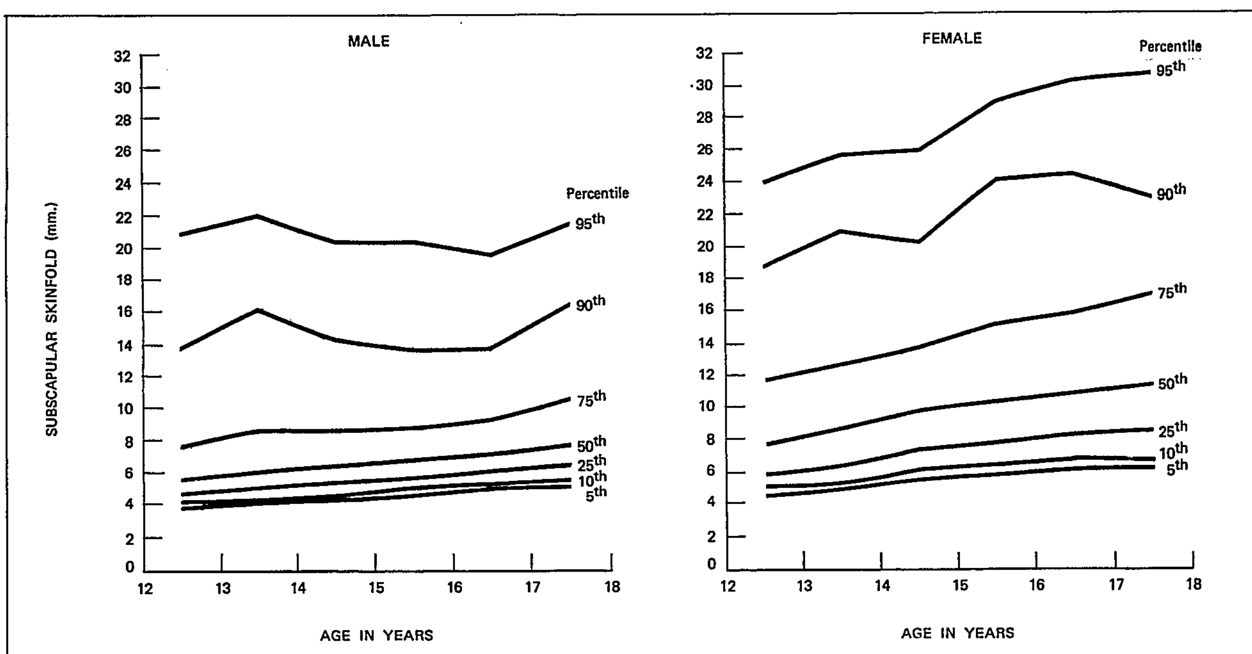


Figure 2. Distributions by selected percentiles of the subscapular skinfold of U.S. youths, by age and sex.

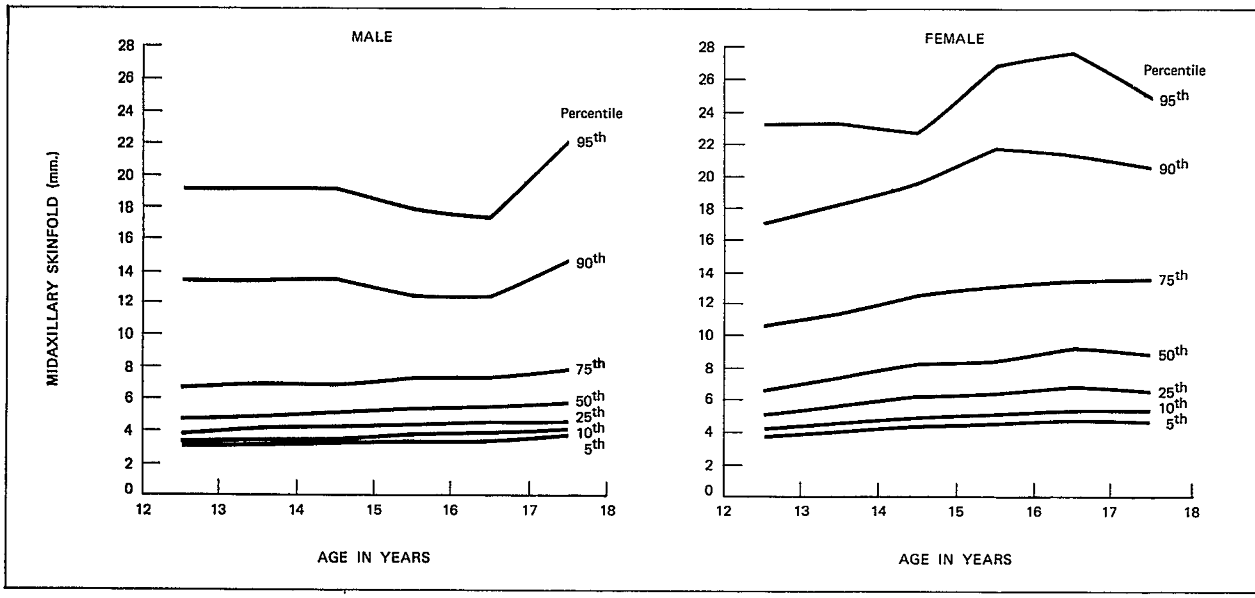
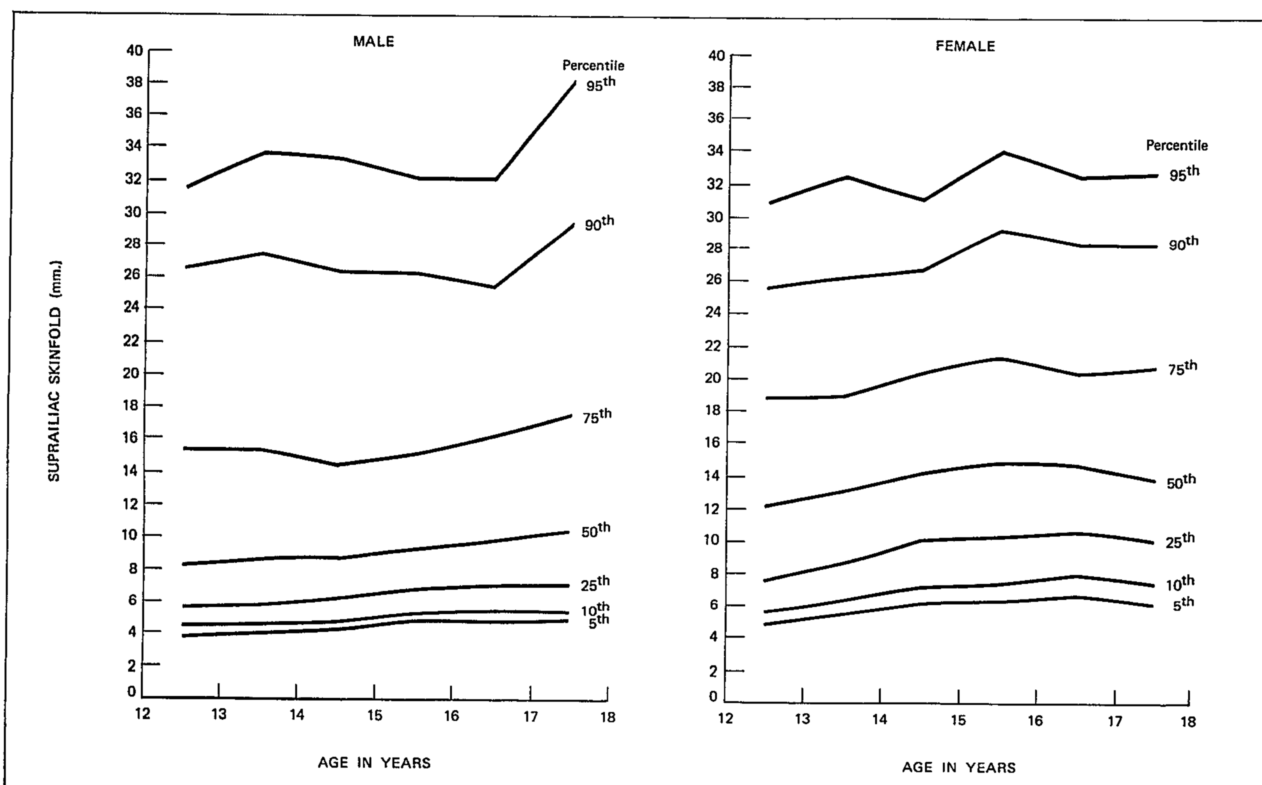


Figure 3. Distributions by selected percentiles of midaxillary skinfold of U.S. youths, by age and sex.



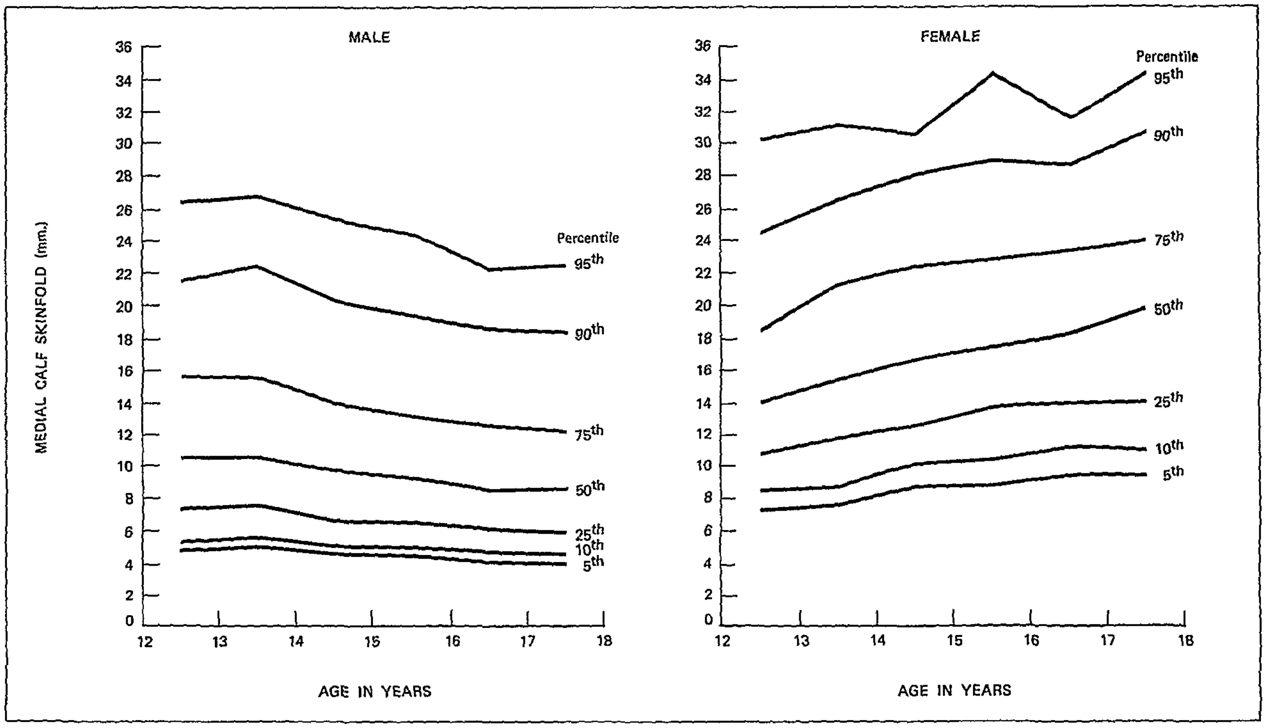


Figure 5. Distributions by selected percentiles of medial calf skinfold of U.S. youths, by age and sex.

sample sizes of Cycle III, it is difficult to ascribe it to sampling error.

For the triceps, medial calf, and subscapular skinfolds, the medians for girls show a consistent increase from 12 through 17 years. On the other hand, the curves for boys show basic differences among the five sites. The three skinfolds which reflect trunk fat (subscapular, midaxillary, and suprailiac) display the same general pattern of increase as noted above for girls, though the slopes of the lines joining the medians are less, suggesting a slower rate of accumulation of fat in boys than in girls. In contrast with the pattern for girls, the median skinfolds for the triceps and medial calf generally decrease with age, indicating a relative loss of fat in the arms and legs in boys during adolescence.

In terms of absolute values, the greatest medians are to be found for the suprailiac and the medial calf skinfolds. The percentile distributions of these two overlap a great deal, and it is therefore difficult to make positive statements about one of the two skinfolds having greater values than the other. However, with respect to the medians, thicker skinfolds are to be found at the medial calf among girls. The same is true in boys 12-14 years, but thereafter, as the medial calf medians decrease, those for the suprailiac fold become greater.

The skewness in skinfold distribution was quantified by dividing the difference between the 95th and 50th percentiles by the difference between the 50th and 5th.[b] Thus a symmetrical distribution would have a value of 1.00. Skewness values are shown in table 6. In all cases the curves were skewed to the right, as evidenced by values in excess of 1.00 and they were frequently markedly so, with values sometimes greater than 6.0. Greater skewness was noted for trunk than for limb fat.

Sex Differences

The differences in skinfold thicknesses between boys and girls are twofold. First, girls

[b]This method was devised because of its simplicity. While it is recognized that there are other measures, e.g., the computation of the third moment about the mean, they are much more complex in their calculation and yield equivalent information.

may be observed, at any site and at any age, to have greater median thicknesses than do boys. At the subscapular and suprailiac sites, the differences between male and female medians show no pattern of change; at the midaxillary site, the differences become greater with age.

Boys and girls differ also in the curves of skinfold thickness and age for the triceps and medial calf. While the medians increase with age among girls, there is a persistent decrease in boys from 12 through 17 years. This decrease serves to accentuate the sexual dimorphism by 17 years. By that age the 50th percentile values for girls are more than two times those for boys. In fact, the male medians for either skinfold fall below the 5th percentile values for females.

In contrast to the greater skinfold thicknesses among females, there is a greater skewness to be seen, at any skinfold and at any age, among males (see table 6). With five skinfolds and six age groups, 30 skewness comparisons are possible; greater values are seen among males in all 30. (Note that this is a relative matter since greater skinfold thicknesses occur among females.)

Race Differences

Tables 7-11 present the distributions of the skinfolds for whites and Negroes separately. The medians are graphed in figures 6-10. For the limb skinfolds, whites have markedly greater thicknesses than do Negroes of the same age and sex. Within each sex, the shapes of the curves joining the medians for the limb skinfolds are quite similar; i.e., the 50th percentile values are generally decreasing in males while increasing in females. The increases in the medial calf skinfold from year to year are greater and more regular in white than in Negro girls; the latter display an irregular curve though the sample size

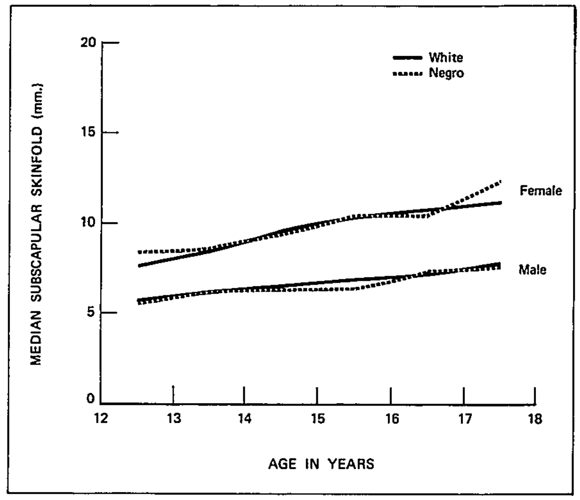


Figure 7. Median subscapular skinfold of U.S. youths, by age, sex, and race.

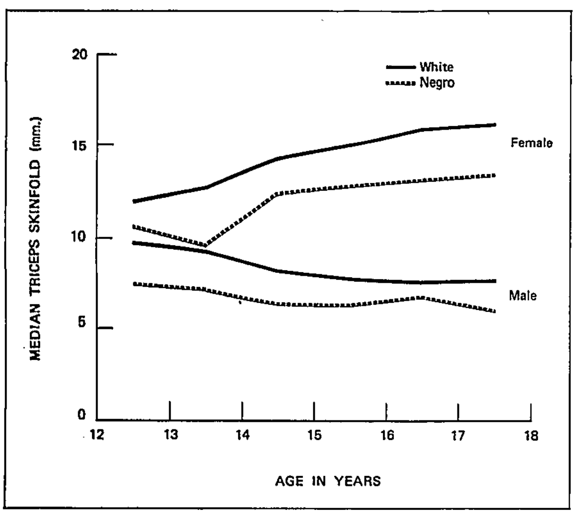


Figure 6. Median triceps skinfold of U.S. youths, by age, sex, and race.

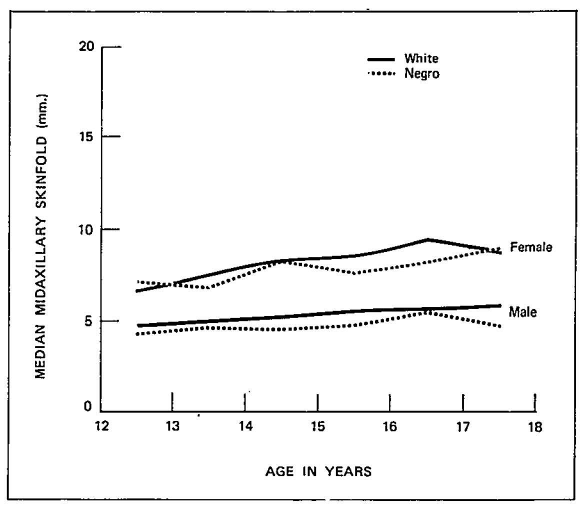


Figure 8. Median midaxillary skinfold of U.S. youths, by age, sex, and race.

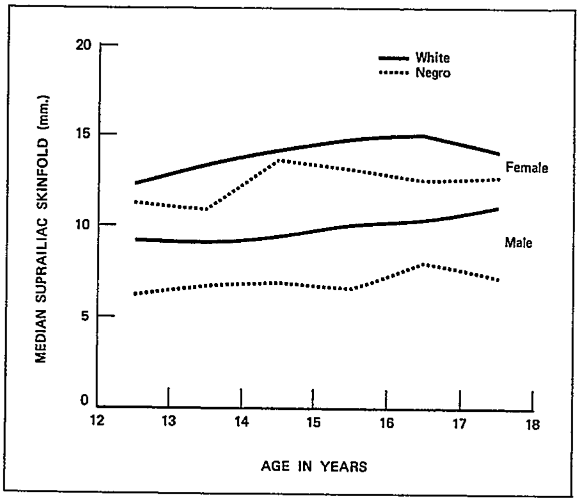


Figure 9. Median suprailiac skinfold of U.S. youths, by age, sex, and race.

of the Negroes is smaller, which may contribute to the irregularity.

Racial differences in trunk skinfolds vary with respect to the site being discussed. For the median subscapular fold, no systematic differences are to be seen, in either sex, between whites and Negroes. For the midaxillary, whites have slightly greater medians than do Negroes, with more consistency noted among boys. As far as the suprailiac fold is concerned, racial differences are the greatest of any of the three trunk skinfolds. This difference is especially marked among boys, with the white medians being on the order of 50 percent greater than those of Negro boys of the same age group.

Skewness coefficients are presented for whites and Negroes in table 12. As when the races were combined, the trunk distributions are more highly skewed than those of limb folds. However, the magnitude of the trunk/limb dichotomy is greater among whites.

Relationships to Data from Cycles I and II

The triceps and subscapular skinfolds were measured in all three cycles of the HES and hence have now been described throughout the age range from 6 through 79 years.[5,6] In figures 11 and 12 the medians are graphed against age, males and females separately, for 6-21 years. (The 21.5 year plot represents the midpoint of those subjects 18-24 years old.) The figures show the changes in median skinfold from 6 years of age into the adult period in both sexes, all races combined. The differences between the sexes in the thickness of both skinfolds are clearly delineated and exist at all ages.

For the triceps fold, the curves are, as noted above, markedly different in shape for the two sexes, the focus of the difference centering at adolescence. From 6 years, the medians increase

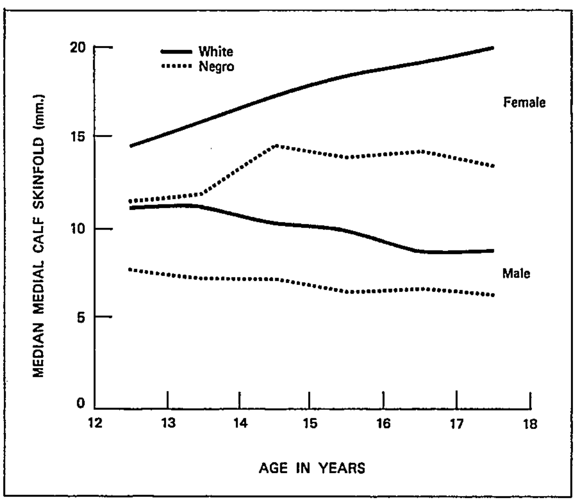


Figure 10. Median medial calf skinfold of U.S. youths, by age, sex, and race.

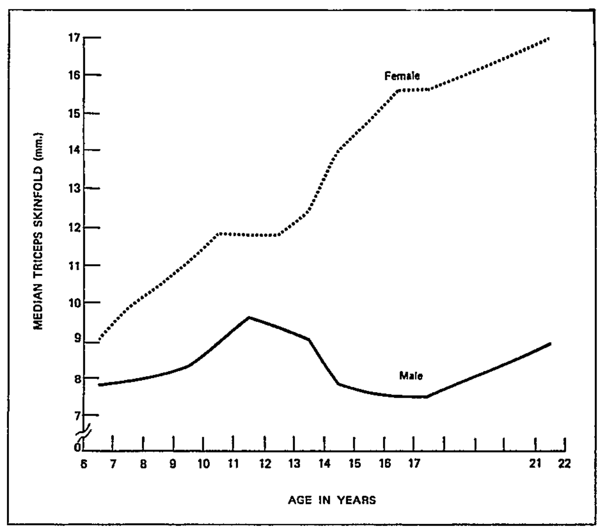


Figure 11. Median triceps skinfold of U.S. males and females 6-21 years of age.

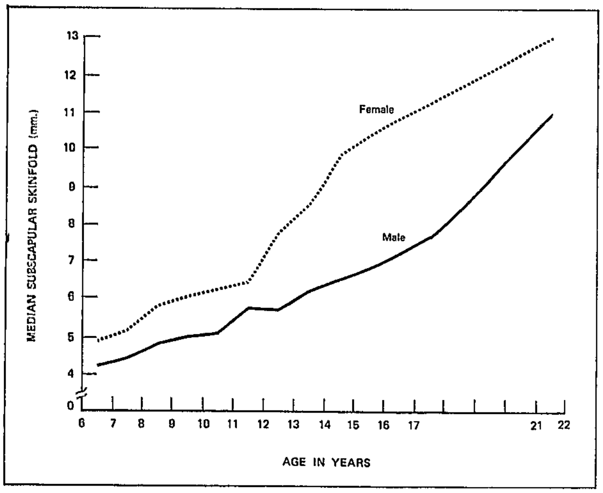


Figure 12. Median subscapular skinfold of U.S. males and females 6-21 years of age.

in both boys and girls, boys reaching a maximum thickness in the 11 and 12 year age groups; in girls the medians level off at 10½-12½ years. Thereafter the sexual dimorphism increases markedly. The decrease in median triceps thickness in males is such that, in the 15-17 year groups, the medians are less than those observed at 6-8 years. The 18-24 year group median indicates another increase in males from this late adolescent "low" to a value of 12.0 mm., according to data from Cycle I, in the 25-34 year group.

Until 11½ years of age, the subscapular skinfolds increase in males and females in parallel fashion, though females have consistently thicker medians by about 25 percent. From 11½ years on, however, the sex differences increase, with females adding fat more rapidly than before, as inferred from changes in the medians. The apparent rate in males remains the same. Both sexes continue to display increases into adulthood until the 5th and 6th decades.

Correlations Among Skinfolds

Tables 13 and 14 present the correlations between pairs of skinfolds by age, sex, and race, as well as for combined categories. Data from only those individuals on whom all skinfolds were measured were utilized, and the sample sizes are therefore less than those given in tables 1-5.

For any pair of skinfolds, the correlation is quite high and is greater than 0.6 for the 450 values of both tables except in seven cases, which were in the 0.56-0.59 range. All values were positive. Thus, there is a strong tendency for individuals who have a greater thickness of subcutaneous fat at one site to be correspondingly fatter at other sites, regardless of their age, sex, or race.

In all but a very few instances, the correlations among boys are higher than among girls, indicating somewhat greater independence of skinfold thicknesses in girls from 12 through 17 years. In fact, the seven low values referred to in the preceding paragraph all occur in girls.

With respect to race, higher correlations generally are to be found among Negro boys than white boys of the same age. From the age-grouped values of table 14 it can be seen that the r values among Negro boys are higher than the corresponding ones for whites for all 10 skinfold pairs. Among girls racial differences are not clear and no pattern emerges.

The correlations among all possible pairs of skinfolds were analyzed, as shown in table 15, in an attempt to discern patterns. Within each age-sex-race group, the correlations for all pairs of skinfolds were ranked from 1 (lowest) through 10 (highest). For example, among 12-year-old males, the lowest correlation was noted for the subscapular/medial calf skinfolds and the highest for the subscapular/midaxillary skinfolds. The ranks of each pair were summed for males and for females; thus, the pair with the highest sum would yield the highest correlations for the years 12-17, as determined by relative rankings.

As one might expect, the highest correlations were to be found with correlations of one trunk skinfold with another. Thus, among both males and females, the subscapular/midaxillary correlation was the highest; in fact, this pair had the highest r's for every age group in both males and females. The triceps skinfold correlated highly with the medial calf, though not as well as the trunk folds correlated with each other. The triceps fold also correlated moderately well with the three trunk sites. On the other hand, the correlations of the medial calf skinfold with the three trunk folds were the lowest of all in both males and females.

The rankings of individual skinfolds may be determined by summing the ranks of all of the correlation coefficients in which a particular one appears. For example, adding the ranks of all r's involving the triceps fold, regardless of the other skinfold, provides an overall indication of the strength of the correlation of the triceps with the other four skinfolds. Among girls, the subscapular skinfold was associated with the highest correlations with other skinfolds, while the midaxillary ranked second and the suprailiac third. Among boys, the suprailiac fold was associated with the highest values, while the midaxillary and subscapular folds clustered together in the second spot. However, the consistency of these observations is much higher among girls than among boys.

Geographic Differences

Tables 16-20 present the skinfold distributions by geographic region, age, and sex. Racial groups are combined and the composition of each region reflects its own racial makeup. No real differences are to be observed among the four regions except that slightly smaller medians tend to exist for children from the South. These differences, however, are almost always less than 1.0 mm. and may reflect the greater proportion of Negroes among the population of that section of the country.

Triceps Skinfold Thickness by Age and Weight

Tables 21-35 give the distribution of the triceps skinfold thickness by age for weight categories from below 30 to 100 kg. or more. Such tables were also presented for the 6 to 11-year-old children of Cycle II.[6] Their utility stems from the knowledge that a given body weight may contain a high or a low proportion of fat, and the evaluation of this relationship in individual children is an important feature of a clinical examination. These tables allow an objective evaluation of the individual relative to the triceps skinfold, and their use is described in the report on Cycle II skinfolds.[6] As an example, it may be seen that 90 percent of 15-year-old girls weighing 55-60 kg. (121-132 lb.) may have triceps skinfolds 9.6-24.3 mm. thick. Obviously, within any weight category, there will be striking variation in fatness. The consideration of triceps fold thickness relative to weight, and weight relative to height,[12] can help materially in the evaluation of the degree of fatness.

Comparison With Other Studies

While it is possible to compare the HES data to those from other studies, the significance of such an exercise would, more often than not, be uncertain and frequently comparisons might even be meaningless. To compare the Cycle III distributions to the results of other studies of American youths would primarily test the sampling variability of the latter. The Health Examination Survey utilized the most sophisticated methods possible to insure an accurate representation of the total U.S. population and of the four geographic regions noted above. Other studies have sampled far more restricted groups with methods which could only increase sampling variability; hence, any differences noted would be difficult to interpret.

Likewise, to compare the Cycle III data to studies from elsewhere in the world would be to ignore the fact that the amount of body fat is highly responsive to the environment and, again, one would be hard put to ascribe differences to genetic factors, hereditary factors, or interactions of the two.

On the other hand, one detailed comparison may be made and may prove informative even though the interpretations of differences may be difficult. Scott's study[13] of children from the London schools is noteworthy because of its comprehensive nature, over 25,000 children being measured. In addition, his data form one of the core samples in the growth standards for British children[11] widely used throughout the United Kingdom. Figures 13 and 14 present the medians and the 10th and 90th percentiles for the HES and the London County Council (LCC) children for the triceps and subscapular skinfolds (the two measured in the LCC survey) by age and sex.

The median triceps skinfolds are greater among American youths of either sex than their English age peers; though these differences are small, they are consistent throughout the age range 12-17 years. The reverse is, in general,

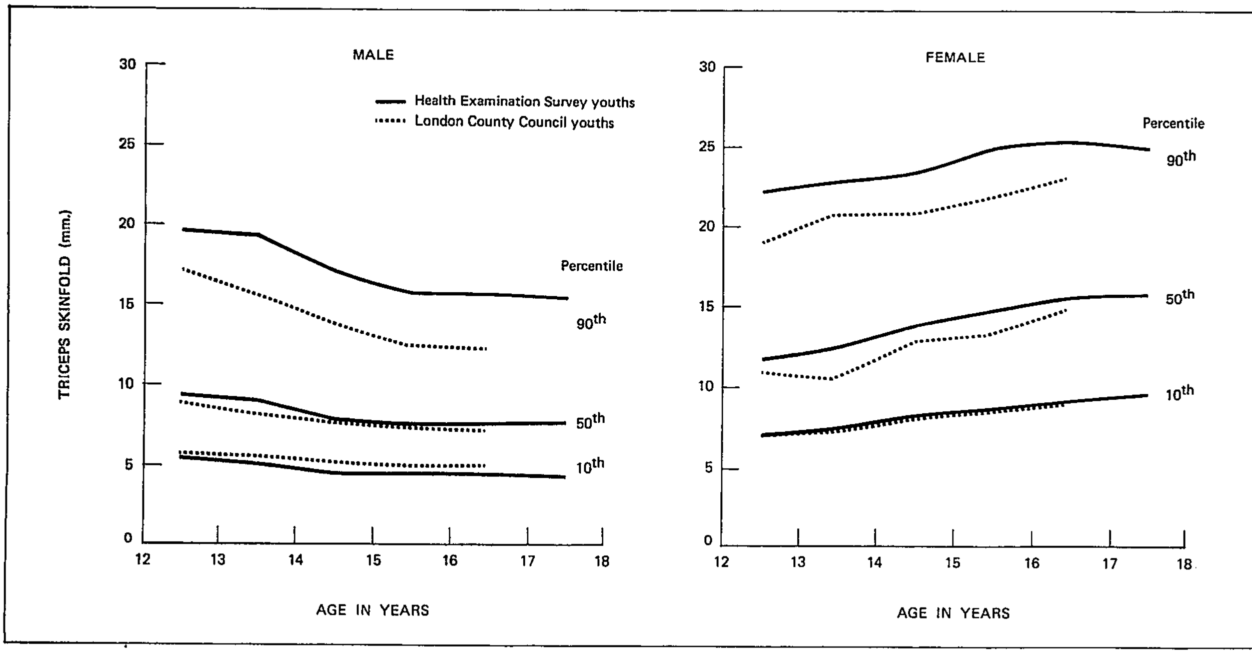


Figure 13. Comparison of triceps skinfold of U.S. and English youths: 10th, 50th, and 90th percentiles.

true for the subscapular skinfold; the medians are greater among the boys and girls of the London sample. This is in agreement with comparisons made between the London and American children between 6 and 11 years.[6]

At the 10th percentile, London males display higher values for both skinfolds. The same is true for the subscapular fold in females, but, in the case of the triceps, American females have higher values after the 13th year.

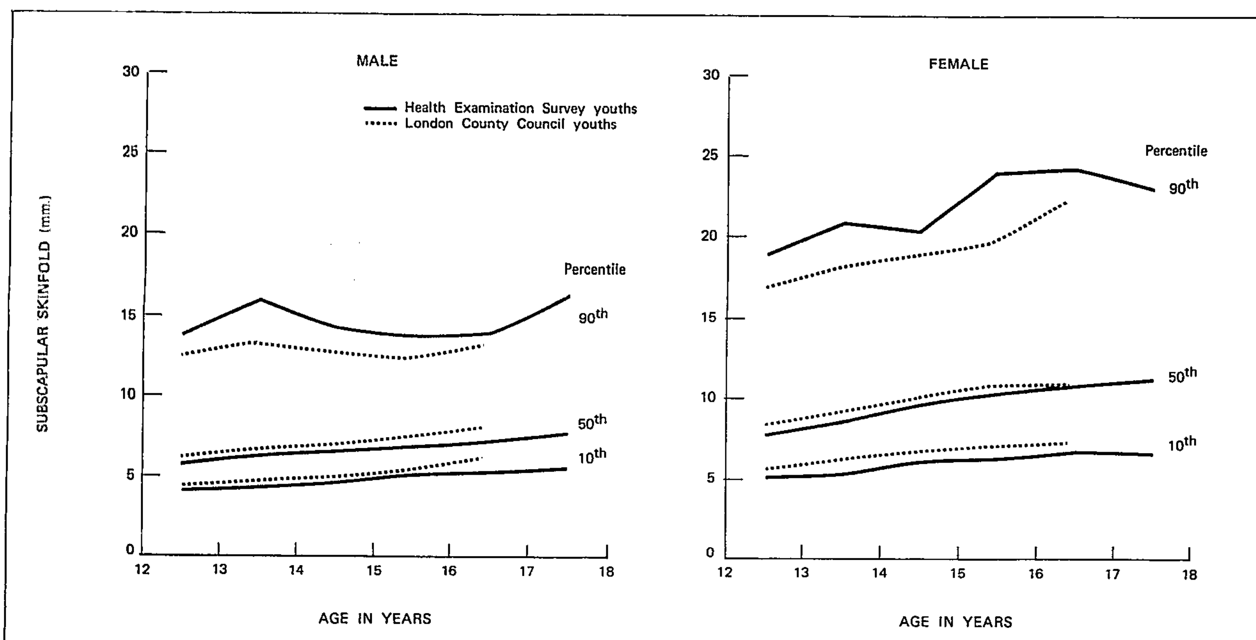


Figure 14. Comparison of subscapular skinfold of U.S. and English youths: 10th, 50th, and 90th percentiles.

On the other hand, at the 90th percentile, greater values are to be found among American youths of similar age and sex, regardless of skinfold. These differences exceed, in some cases, 3.0 mm., and indicate that greater fatness is to be found in the HES sample, compared to the London sample, as evidenced by the skewing of the distributions.

The shapes of the curves constructed by joining the values for similar percentiles tend to be the same, with few differences occurring. Some of the similarities may be of particular interest; for example, the increase in the 90th percentile value of the subscapular fold in 13-year-old boys from both samples compared to adjacent values. The parallel nature of the increase in English and American boys suggests the operation of factors related to adolescent development.

DISCUSSION

The publication of these data on subcutaneous fat distribution among U.S. children 12-17 years old completes data for a 74-year age range and provides comprehensive standards for the population from 6 years onward. This represents the first available data of such magnitude which has utilized sophisticated sampling techniques insuring a national probability sample. Thus, the population of the United States, as it was in the 1960's, is adequately depicted. Because the significant differences between Negroes and whites in the amount of subcutaneous fat have now been recognized, black and white American children may now be evaluated on standards specific for their own race.

Age and Sex Differences

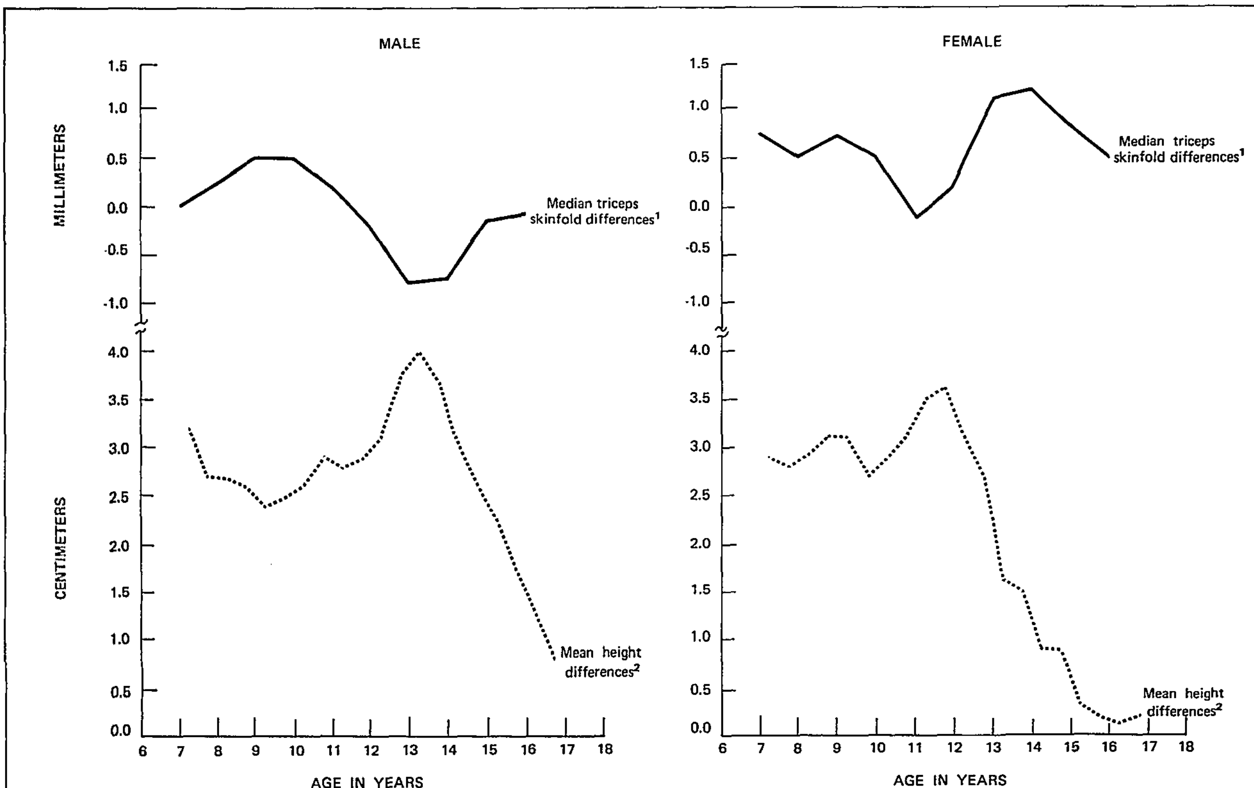
The changes in subcutaneous fat that are documented in this report for the adolescent years as the child becomes an adult reveal significant differences among the sites which are related to sex. By and large, the increase in skinfold thickness in girls is persistent from 12 through 17 years. Among white girls the medians, at 17 years, for the midaxillary and suprailiac skinfolds are less than those for 16-year-olds. In view of sample size and sampling technique, this is not likely to be fortuitous and, therefore, two possible explanations exist. First, this may represent a true decrease; i.e., if the same girls comprised the 16 and 17 year subgroups, these differences would still exist and would be due to a decrement in growth. Such a decrement might occur, for example, from a conscious weight reduction, through dieting, due to peer-group pressure. However, since the HES sample is cross sectional, this cannot be determined with complete confidence. Second, some exogenous factors may have affected the 17-year-olds differently than the 16-year-olds, thus leading to differences in the medians. The absence of a truly national catastrophe argues against this explanation.

Viewing the combined data of Cycles II and III, it appears that the triceps and subscapular skinfolds among girls display similar growth patterns. There is a steady increase from 6 through 17 years, except for a plateau lasting for 2 years. In the case of the triceps, this plateau occurs at 10-12 years and coincides with the period of rapid growth in height as seen in figure 15. The plateau for the subscapular skinfold occurs at ages 8-10 years.

Among boys, as noted earlier, fundamental intersite differences in the pattern of age changes are clear; these changes are related to other aspects of adolescent growth. Changes in trunk skinfolds (subscapular, midaxillary, suprailiac) show an overall increase which seems to follow quite well the observations made in Cycle II of the HES.

The decrease for boys in the triceps and medial calf skinfolds is consistent for both sites, and the rate of change for each age group is similar. This phenomenon has been observed by other investigators and is believed to be a genuine difference. For example, the findings of Johnston and Malina[14,15] based on measurements of tissue thicknesses on radiographs support these findings as do those of other investigators.[16,17]

The decrease in limb fat in boys is clearly related to their growth spurts. Changes in the median thickness of the triceps and medial calf skinfolds are closely related to the increased increments between mean heights associated with the adolescent spurt.[18] There is a definite relationship between the period of most rapid growth in males and the decrease of triceps skinfold thickness, which is shown in figure 15.



[1] Smoothed by a two-period moving average.
[2] Smoothed by a three-period moving average.

Figure 15. Comparison of pseudo velocity curve for triceps skinfold with pseudo velocity curve for height of U.S. males and females 6-17 years of age.

The meaning of the decrease in the thickness of extremity fat in boys during adolescence is not at all clear. As Tanner[7] has noted, a decrease in the thickness of the fat ring about the arm does not have to mean a loss of fat, for an increase in the volume of the underlying lean tissues, with a constant fat volume, would result in a reduced thickness of fat as it "inevitably...would be stretched out thinner" under these conditions. The measurement of subcutaneous tissue widths, either on X-rays or using skinfold calipers, tells nothing of changes in the size or number of adipose tissue cells.

Additional information may be gained from the calculation of the estimated cross-sectional area of fat in a circle at the level of the triceps skinfold. Since the circumference of the arm was measured at this level, this parameter is easily derived, assuming that the triceps skinfold, as a double layer of adipose tissue, equals the diameter of fat at this site.

Table 36 presents the median cross-sectional areas of the upper arm and of the muscle-bone complex for each age group in Cycles II and III by sex. Cross-sectional areas of fat have been derived by subtraction of the medians. Girls display steadily increasing areas of fat from 6 through 15 years, paralleling the increase noted in the thickness of the triceps skinfold. The area of fat of the 16-year-old group is essentially the same (6 $mm.^2$ difference) as that of the 15-year-olds, while the 17-year-olds show an increase.

The derived cross-sectional areas of fat among boys increase consistently through age 13. For the next 2 years, i.e., ages 14 and 15, there is a decrease, followed by a very slight increase at 16 and a large increase at 17 years of age.

Several conclusions may be drawn from table 36. In girls no fat loss occurs in the upper arm since both the triceps skinfold and the area of fat increase with age. Because there is no further increase in muscle-bone area after age 15, all further increase in arm circumference seen in table 36 must be due to increased fat.

In boys the decrease in derived cross-sectional areas of fat from ages 13 through 15, coupled with the decrease in median triceps skinfold thickness, is evidence for an actual loss of fat in this anatomical region. At other ages when the triceps fold decreases but the cross-sectional area of fat increases, there seems to be no absolute loss of fat, but instead a thinning of the ring of fat due to expansion of underlying tissues.

The relative composition of the arm may be examined by expressing the cross-sectional area of fat as a percentage of arm area; this may be seen in figure 16, again for Cycles II and III data combined. The differences between boys and girls are quite striking. Before adolescence, the relative composition of the arm undergoes little change, although girls have a higher percentage cross-sectional area of fat. As they enter their growth spurt, there is a relative decrease in fat due to the larger increase in muscle and bone (figure 15). As the rate of growth in muscle and bone decreases, the relative fat content again becomes greater.

The marked decrease in relative arm fat in boys occurs from 12 through 16 years. The steepest decrease, from 13 through 15 years, is accompanied by an absolute loss of cross-sectional area of fat (table 36).

Among girls, the derived cross-sectional area of fat increased steadily from 6-17 years, except at age 16, when it leveled off, and the muscle-bone area increased from 6 through 15 years. Thus at ages 10-12 years, when the median triceps fold remains unchanged, the increase in upper arm circumference is due to the expansion of the muscle-bone mass rather than to fat. In contrast, after 15 years, when the muscle-bone area remains the same, the increase in arm circumference is due to an increase of subcutaneous fat.

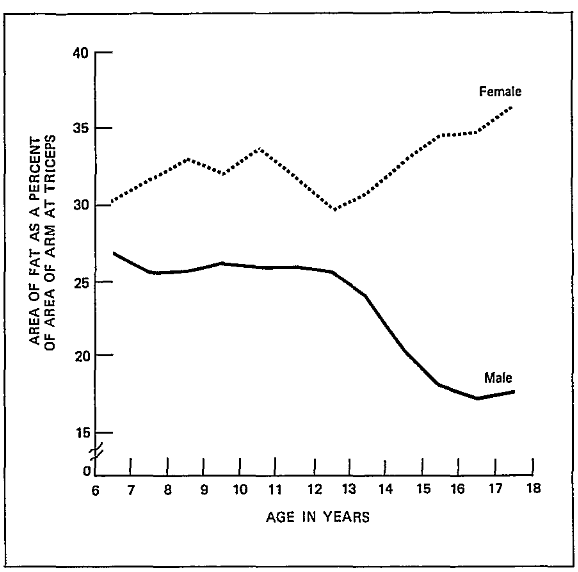


Figure 16. Percentage of cross-sectional area of arm comprised of fat, by age and sex.

With respect to the five skinfolds, sexual dimorphism during adolescence is greatest for the triceps and the medial calf. The ratio of the median for females to that of males at 17 years is as follows:

Suprailiac:	1.3
Midaxillary:	1.5
Subscapular:	1.6
Triceps:	2.1
Medial calf:	2.2

The female/male ratio for extremity skinfolds increases steadily during the adolescent years. The relative sex difference in extremity fat is about the same for the triceps as for the medial calf, which is contrary to the suggestions of Tanner,[7] although the data on which he has based them may be subject to sampling error.

Race Differences

Differences between whites and Negroes reported for the Cycle II sample[6] persist throughout the ages of 12-17 years: whites have greater medians for the triceps, when compared to Negro children of the same sex and age, but not for the subscapular skinfold. On the other hand the midaxillary skinfold medians are slightly greater in white girls at ages 12-17 years, a difference not observed in the 6-11 year old group.

The median medial calf skinfold changes from 12 through 17 years in a manner similar to that for the triceps in all four race/sex groups, which is as expected.

The median thicknesses of the suprailiac skinfold do not conform to the pattern of the subscapular or midaxillary folds, in that whites have markedly greater values than do Negroes. However, Negro girls have greater medians than do white boys of the same age, so that the influence of sex-related factors is still strong. Apparently the subcutaneous fat on the trunk displays a gradient as one moves from the back down and around to the crest of the ilium with respect to race; greater differences between the medians are associated with more inferior skinfolds on the trunk.

In the report on skinfolds from the HES Cycle II,[6] it was suggested that extremity fat (as indicated by the thickness of the triceps skinfold) differed in whites and Negroes because of the combined effects of racial and environmental factors, while trunk fat (as indicated by the midaxillary and subscapular folds) differed because of the effects of environmental factors alone. This was based on the observation that the racial differences in triceps fold thickness of children 6-11 years were of two degrees: the medians were greater among whites than Negroes and there was also greater skewness among whites, the comparisons being made to groups of the same age and sex. At the same time, racial differences in the two trunk skinfolds existed *only* in the degree of skewness, whites showing the greater distortion of the curves. It was suggested that environmental factors would tend to skew the curves and therefore environmental differences would result in differentials in skewness. Racial (i.e., hereditary) differences would result in a shift of the distribution with corresponding differences in the medians.

The data from Cycle III reinforce these conclusions, and they are combined with those from Cycle II in table 37, which presents the results of comparing the differences in the degree of skewness (given in table 12) between Negroes and whites at each age and for all five skinfolds. Greater skewness is seen in whites for the subscapular and midaxillary skinfolds in 31 of 46 comparisons which differed. Assuming, as before, that skew results from environmental pressures, and since the major differences between the races in the skinfolds at these two sites are in the skewness and not in the medians, it is concluded that Negro/white differences at these sites reflect environmental factors.

Again with regard to skewness, the reverse is true for the limb skinfolds. Greater asymmetry is seen in the triceps and medial calf skinfolds among Negroes in 26 of 35 comparisons. On the other hand, in both sexes, the median triceps and medial calf skinfolds are consistently greater in whites. The hereditary factors, which presumably affect the medians, seem to work contrary to, and to be more important than, environmental factors.

The suprailiac skinfold distributions seem more similar, in terms of asymmetry, to those of the limbs than to those of the trunk, and one would conclude that the greater median values among whites therefore reflect hereditary mechanisms leading to fat deposition around the pelvic girdle.

Table 37 also shows the comparisons of males and females, races combined. For every skinfold, greater skewness is noted among males more often than among females. If the greater physical susceptibility to environmental factors of males is considered, support is given to the assumption that skewness of skinfold distributions is produced by environmental influences.

Finally, the five skinfolds may be ranked, races and sexes combined, by their overall skewness. This can be done by averaging all skewness coefficients for a particular skinfold, resulting in the following:

Midaxillary:	5.37
Subscapular:	4.96
Suprailiac:	4.01
Triceps:	3.07
Medial calf:	2.81

These values were computed only for 12-17 year olds, since the suprailiac and medial calf skinfolds were not measured in Cycle II. In Cycle II, the three skinfolds that were measured ranked as above.

The above ranking of the five skinfolds, in terms of their skewness, was consistent for all four sex/race groups with the following exceptions: among Negro males, the suprailiac skinfold yielded the highest average skewness and, among Negro females, there was a reversal of the midaxillary and subscapular skinfolds. All of this suggests that trunk fat, particularly that in the subscapular and midaxillary regions, is more responsive to the environment than limb fat and that either of these two skinfolds may be a better measure of adiposity in nutritional surveys than is the triceps skinfold.

Correlations Among Skinfolds

The high intercorrelations among all skinfold pairs suggests that the thickness of the adipose layer in an individual at one site is strongly dependent upon the thicknesses at other sites. The generally high values for the midaxillary and subscapular folds suggests that either may be the best single skinfold during adolescent years to use in estimating body fat, although it is clearly better to measure others as well, if at all possible. The subscapular and triceps, the two folds most frequently measured, probably provide acceptable estimates of body fat. The nearness of the midaxillary to the subscapular site suggests that its addition would not add much more information. (Their correlations are also consistently the highest.) The difficulty in measuring the medial calf skinfold and the relatively low r values argue against a high priority for its inclusion.

SUMMARY

This report presents and analyzes the distribution of skinfold measurements in United States youths, 12-17 years of age, as estimated from Cycle III of the Health Examination Survey. The thickness of five skinfolds was measured—triceps, subscapular, midaxillary, suprailiac, and medial calf—and the results analyzed by age, sex, race, geographic region, and in relation to youths from outside the United States. As appropriate, data from Cycle II have been included to present a picture of changes in body fatness from 6 through 17 years.

At every site, girls display greater skinfold thicknesses than do boys of the same age. These differences exist at all percentiles and for both Negroes and whites, similar to those found in Cycles I (18-79 years) and II (6-11 years).

In both males and females, the skinfolds of the trunk (subscapular, midaxillary, suprailiac) increase in thickness with age from 12 through 17 years. In girls the median triceps skinfold, after leveling off at ages 10-12 years, continues to increase through 17, while in boys both the triceps and the medial calf folds decrease steadily from 12 through 16 years of age.

Since these patterns of change in the triceps skinfold occur during the period of rapid adolescent growth, they were also examined by deriving the cross-sectional area of fat at the level of the triceps skinfold for each individual from 6-17 years. In addition, the underlying muscle-bone mass was calculated from the upper arm circumference and triceps thickness.

The leveling off of the median triceps skinfold in females at 10-12 years, seen in figure 11, represents the counterpart to the reduction in limb skinfold thickness among males. However, the magnitude of the change is not at all comparable to that observed in males. Thus, it is clear that the increase in upper arm circumference among females 10-12 years is due to an increase of muscle and bone.

In boys, the area of fat at the level of the triceps fold actually decreased from 13 through 15 years of age, then increased from 16 through 17 years. This decrease in cross-sectional area of fat, along with the sharp decrease in triceps skinfold thickness at that time, indicates an actual loss of arm fat at ages 13-15 years, which corresponds to the period of most rapid growth for these boys. It appears that the decrease in triceps fold thickness at other ages is due, not to fat loss, but to the thinning of the fat ring caused by the growth of the underlying muscle and bone.

Racial comparisons reveal greater median skinfold thicknesses in whites than in Negroes of corresponding age and sex for the triceps, medial calf, and suprailiac folds, while no consistent differences were noted for the subscapular and midaxillary folds.

The greater skewness to the right of the subscapular and midaxillary distributions in whites, considered in conjunction with the similarity of the medians for whites and Negroes, suggests that racial differences at these sites result primarily from the operation of environmental factors. At the other sites, both hereditary and environmental factors seem to be operating.

The generally high correlations between pairs of skinfolds indicate a tendency throughout the entire body to fatness or leanness in the individual. However, those correlations in which one of the three trunk folds was involved tended to be the highest, while those involving the medial calf were the lowest.

It is concluded that the measurement of the triceps and subscapular skinfolds, being the ones most frequently taken, offer acceptable estimates of body fat, although others may be desirable for specific purposes. The midaxillary fold, due to its high correlation with the subscapular, yields no additional information. The high correlation of the suprailiac with the subscapular, and its relatively high error of measurement, suggest that its use be reserved for specific purposes. The high correlation of the medial calf with the triceps, its low correlation with all others, and its high error of measurement, argue against its use, as a general rule. The apparent responsiveness of the subscapular fold to environmental factors, the acceptably lower errors of

measurement, and its high correlation with all others, lead to the conclusion that it is probably the single most useful skinfold measurement in the study of adiposity caused by dietary intake.

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LIST OF DETAILED TABLES

Table 1. Triceps skinfold of youths by sex and age at last birthday: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Sex and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile 5th	10th	25th	50th	75th	90th	95th
			In millimeters									
Male												
12 years	643	2,032	10.7	5.83	0.27	5.1	5.5	6.8	9.4	13.3	19.6	23.3
13 years	626	2,006	10.5	5.85	0.25	4.5	5.2	6.7	9.1	12.9	19.3	22.6
14 years	617	1,949	9.5	5.60	0.27	4.2	4.7	6.0	7.8	12.0	17.1	20.8
15 years	613	1,900	9.0	5.11	0.25	4.3	4.7	5.8	7.6	10.7	15.8	20.7
16 years	555	1,833	8.9	4.94	0.28	4.2	4.7	5.8	7.5	11.1	15.8	20.2
17 years	489	1,764	9.0	5.43	0.24	4.1	4.6	5.5	7.5	11.4	15.6	20.5
Female												
12 years	547	1,970	12.9	5.82	0.29	6.1	7.0	8.8	11.8	16.0	22.2	25.2
13 years	582	1,946	13.6	6.07	0.28	6.4	7.3	9.2	12.4	17.1	22.8	25.5
14 years	586	1,901	14.8	6.13	0.23	7.1	8.3	10.7	14.0	18.5	23.3	26.7
15 years	502	1,848	15.8	6.60	0.37	7.4	8.6	11.6	14.8	19.5	25.1	29.4
16 years	535	1,787	16.5	6.91	0.41	7.7	9.2	11.8	15.6	20.8	25.5	29.7
17 years	468	1,743	16.5	6.24	0.41	8.1	9.6	12.1	15.8	20.5	25.0	29.1

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

Table 2. Subscapular skinfold of youths by sex and age at last birthday: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Sex and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile 5th	10th	25th	50th	75th	90th	95th
			In millimeters									
Male												
12 years	643	2,032	7.3	5.44	0.22	3.7	4.1	4.7	5.7	7.6	13.7	20.8
13 years	626	2,006	8.1	6.18	0.22	4.1	4.3	5.1	6.2	8.5	16.1	22.1
14 years	618	1,951	8.1	5.62	0.29	4.2	4.6	5.4	6.5	8.5	14.2	20.4
15 years	613	1,900	8.3	5.42	0.22	4.5	5.1	5.7	6.8	8.8	13.7	20.4
16 years	556	1,836	8.5	4.92	0.22	5.0	5.3	6.1	7.2	9.2	13.8	19.5
17 years	487	1,758	9.3	5.16	0.24	5.1	5.6	6.5	7.7	10.6	16.4	21.4
Female												
12 years	546	1,968	9.8	6.22	0.27	4.5	5.1	5.9	7.7	11.7	18.8	23.8
13 years	582	1,946	10.7	6.84	0.36	5.0	5.3	6.5	8.5	12.7	20.9	25.6
14 years	586	1,901	11.5	6.72	0.25	5.5	6.2	7.4	9.7	13.7	20.3	25.8
15 years	501	1,845	12.4	7.23	0.32	5.9	6.4	7.7	10.3	15.1	24.0	28.9
16 years	536	1,789	13.1	7.56	0.39	6.2	6.8	8.1	10.8	15.7	24.4	30.2
17 years	469	1,746	13.3	7.72	0.49	6.2	6.7	8.2	11.3	17.0	23.0	30.6

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

Table 3. Midaxillary skinfold of youths by sex and age at last birthday: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Sex and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In millimeters									
Male												
12 years	643	2,032	6.3	4.94	0.20	3.1	3.2	3.8	4.7	6.6	13.4	19.1
13 years	626	2,006	6.6	5.42	0.18	3.1	3.4	4.1	4.9	6.9	13.5	19.1
14 years	617	1,947	6.7	5.72	0.30	3.2	3.4	4.2	5.1	6.8	13.6	19.3
15 years	613	1,900	7.0	5.55	0.23	3.4	3.8	4.4	5.4	7.3	12.5	17.9
16 years	556	1,836	6.9	4.82	0.24	3.4	3.8	4.5	5.5	7.3	12.4	17.4
17 years	488	1,762	7.6	5.71	0.30	3.6	4.1	4.6	5.7	7.9	14.8	22.2
Female												
12 years	546	1,967	8.6	5.92	0.26	3.6	4.2	5.1	6.7	10.6	17.1	23.3
13 years	582	1,946	9.3	6.29	0.33	4.0	4.5	5.6	7.4	11.3	18.2	23.4
14 years	586	1,901	10.2	6.17	0.22	4.4	4.9	6.3	8.4	12.6	19.5	22.8
15 years	502	1,847	10.9	7.00	0.34	4.5	5.2	6.4	8.5	13.2	21.9	26.8
16 years	536	1,789	11.2	6.94	0.34	4.8	5.4	6.8	9.3	13.6	21.4	27.7
17 years	469	1,746	11.0	6.91	0.48	4.7	5.4	6.6	8.8	13.7	20.7	24.9

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

Table 4. Suprailiac skinfold of youths by sex and age at last birthday: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Sex and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In millimeters									
Male												
12 years	640	2,027	11.8	9.14	0.33	3.8	4.4	5.7	8.3	15.3	26.6	31.6
13 years	626	2,006	12.2	9.49	0.35	4.0	4.6	5.8	8.7	15.3	27.6	33.8
14 years	618	1,951	12.1	9.39	0.43	4.2	4.7	6.3	8.8	14.6	26.4	33.4
15 years	613	1,900	12.6	9.03	0.37	4.7	5.3	6.8	9.4	15.1	26.4	32.3
16 years	555	1,834	12.6	8.52	0.47	4.8	5.5	7.1	9.9	16.2	25.4	32.3
17 years	487	1,757	13.9	9.83	0.55	5.0	5.5	7.2	10.5	17.6	29.6	38.1
Female												
12 years	545	1,963	13.9	8.36	0.37	4.7	5.6	7.7	12.2	18.7	25.5	30.8
13 years	582	1,946	14.7	8.22	0.37	5.4	6.4	8.7	13.1	18.8	26.2	32.4
14 years	586	1,901	15.5	7.75	0.34	6.2	7.3	10.1	14.1	20.3	26.6	31.2
15 years	502	1,847	16.3	8.42	0.50	6.3	7.4	10.3	14.8	21.4	29.3	34.0
16 years	536	1,789	16.2	8.12	0.49	6.7	8.0	10.6	14.7	20.3	28.3	32.6
17 years	468	1,742	15.9	8.64	0.54	6.1	7.4	10.2	13.8	20.7	28.3	32.8

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

Table 5. Medial calf skinfold of youths by sex and age at last birthday: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Sex and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
Male			In millimeters									
12 years	639	2,021	12.0	6.87	0.28	4.8	5.4	7.4	10.5	15.6	21.5	26.4
13 years	620	1,980	12.3	7.07	0.33	5.0	5.7	7.6	10.6	15.6	22.4	26.9
14 years	612	1,934	11.3	6.98	0.33	4.7	5.3	6.7	9.6	14.0	20.3	25.4
15 years	609	1,888	10.7	6.41	0.31	4.6	5.2	6.7	9.2	13.1	19.4	24.4
16 years	553	1,828	10.0	5.81	0.29	4.1	4.8	6.2	8.4	12.5	18.7	22.3
17 years	487	1,758	9.9	6.18	0.29	4.0	4.5	6.0	8.5	12.2	18.5	22.6
Female												
12 years	536	1,933	15.3	6.76	0.27	7.3	8.5	10.8	14.1	18.7	24.5	30.2
13 years	579	1,936	16.6	7.17	0.31	7.5	8.7	11.7	15.5	21.3	26.5	31.2
14 years	579	1,876	17.8	7.01	0.35	8.7	10.0	12.6	16.8	22.5	27.9	30.6
15 years	497	1,830	18.7	7.75	0.51	8.8	10.4	13.8	17.7	22.8	28.8	34.5
16 years	530	1,768	19.0	7.28	0.34	9.4	11.1	14.0	18.5	23.4	28.6	31.7
17 years	460	1,710	19.7	7.70	0.47	9.4	11.0	14.1	18.9	24.0	30.6	34.4

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

Table 6. Skewness coefficients (difference between the 50th and 95th percentile divided by the difference between the 5th and 50th percentile) by skinfold site, sex, and age at last birthday of youths: United States, 1966-70

Sex and age	Skinfold				
	Triceps	Subscapular	Midaxillary	Suprailiac	Medial calf
Male					
12 years	3.18	7.58	8.60	5.15	2.73
13 years	2.94	7.49	8.04	5.44	2.91
14 years	3.60	5.95	7.58	5.40	3.20
15 years	3.98	5.83	6.25	4.87	3.27
16 years	3.87	5.51	5.60	4.45	3.24
17 years	3.83	5.25	7.84	5.00	3.19
Female					
12 years	2.36	4.88	5.46	2.49	2.36
13 years	2.18	4.89	4.68	2.48	1.97
14 years	1.83	3.85	3.56	2.16	1.69
15 years	1.97	4.18	4.55	2.28	1.87
16 years	1.81	4.25	4.06	2.22	1.47
17 years	1.70	3.79	3.86	2.47	1.63

Table 7. Triceps skinfold of youths by race, sex, and age at last birthday: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Race, sex, and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In millimeters									
WHITE												
Male												
12 years	540	1,747	11.0	5.82	0.28	5.2	5.7	7.2	9.7	13.6	19.8	23.2
13 years	542	1,729	10.8	5.81	0.27	4.8	5.4	7.1	9.4	13.4	19.7	22.6
14 years	526	1,683	9.8	5.59	0.28	4.3	5.0	6.3	8.2	12.5	17.4	21.2
15 years	525	1,646	9.3	5.29	0.27	4.3	4.8	6.0	7.8	11.2	16.4	21.3
16 years	495	1,591	9.1	5.11	0.31	4.2	5.0	5.9	7.6	11.6	16.5	20.5
17 years	417	1,528	9.2	5.47	0.25	4.1	4.5	5.6	7.7	11.6	15.8	20.7
Female												
12 years	455	1,685	13.0	5.78	0.34	6.1	7.1	9.2	12.0	16.0	22.1	25.1
13 years	490	1,667	13.8	5.87	0.31	6.6	7.6	9.6	12.7	17.2	22.7	25.4
14 years	484	1,633	15.1	6.08	0.26	7.3	8.5	11.0	14.2	18.7	23.5	26.8
15 years	424	1,592	16.1	6.65	0.37	7.5	8.8	12.0	15.1	20.0	25.4	29.9
16 years	440	1,540	16.8	6.72	0.40	8.1	9.7	12.3	16.0	21.2	25.5	29.1
17 years	392	1,500	16.8	6.24	0.43	8.5	10.1	12.4	16.3	20.8	25.3	29.5
NEGRO												
Male												
12 years	101	280	8.7	5.19	0.59	3.8	4.7	5.6	7.4	10.3	15.3	23.2
13 years	80	262	8.5	5.82	0.65	3.6	4.2	5.2	7.2	10.3	15.6	25.2
14 years	88	256	7.6	5.39	0.69	3.6	4.1	4.8	6.4	8.4	14.2	19.2
15 years	84	241	6.8	3.08	0.34	3.9	4.2	5.1	6.4	7.7	10.6	14.7
16 years	57	231	7.1	3.26	0.45	4.0	4.3	4.9	6.7	8.9	11.7	12.8
17 years	69	225	7.7	5.11	0.59	4.2	4.6	5.3	6.1	8.5	14.0	15.8
Female												
12 years	88	272	12.2	6.16	0.66	6.0	6.5	7.7	10.6	16.2	22.5	25.6
13 years	91	275	12.0	6.95	0.61	6.0	6.3	7.7	9.8	13.6	23.9	27.2
14 years	101	266	13.6	6.35	0.56	5.5	6.7	10.0	12.5	17.3	22.1	24.6
15 years	73	235	14.1	5.88	0.64	7.2	8.2	10.2	12.8	17.9	22.7	25.8
16 years	93	243	14.9	7.87	1.54	7.0	7.6	9.6	13.1	17.8	26.4	31.5
17 years	74	237	14.5	5.85	1.01	7.1	7.6	10.7	13.4	18.2	23.3	25.8

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

Table 8. Subscapular skinfold of youths by race, sex, and age at last birthday: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Race, sex, and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In millimeters									
WHITE												
Male												
12 years	540	1,747	7.4	5.46	0.22	3.6	4.1	4.7	5.7	7.8	14.0	21.1
13 years	542	1,729	8.2	6.31	0.24	4.0	4.3	5.1	6.2	8.7	16.5	22.3
14 years	527	1,686	8.2	5.67	0.30	4.2	4.6	5.4	6.5	8.7	14.6	20.6
15 years	525	1,646	8.5	5.67	0.24	4.5	5.1	5.8	6.9	9.2	14.8	21.3
16 years	496	1,594	8.6	5.13	0.26	5.1	5.3	6.2	7.2	9.3	15.0	20.5
17 years	415	1,522	9.4	5.04	0.26	5.1	5.6	6.5	7.8	10.7	17.1	22.0
Female												
12 years	454	1,682	9.6	6.16	0.34	4.4	5.0	5.8	7.6	11.6	18.6	23.7
13 years	490	1,667	10.8	6.92	0.41	4.9	5.3	6.5	8.5	12.8	21.3	25.5
14 years	484	1,633	11.6	6.80	0.26	5.5	6.2	7.4	9.7	13.8	20.4	26.3
15 years	423	1,588	12.6	7.41	0.36	5.8	6.4	7.7	10.3	15.3	24.4	30.0
16 years	441	1,542	12.9	7.36	0.42	6.2	6.8	8.1	10.8	15.5	24.0	29.8
17 years	393	1,502	13.2	7.79	0.52	6.2	6.6	8.2	11.2	17.0	23.4	31.0
NEGRO												
Male												
12 years	101	280	6.3	3.92	0.44	4.1	4.2	4.7	5.5	6.5	9.4	16.5
13 years	80	262	7.5	5.30	0.54	4.2	4.4	5.1	6.2	7.6	11.6	17.2
14 years	88	256	7.3	5.29	0.78	4.1	4.4	5.2	6.3	7.6	10.5	15.3
15 years	84	241	6.8	2.89	0.32	4.4	4.8	5.4	6.4	7.5	9.4	11.7
16 years	57	231	7.5	3.14	0.26	4.3	4.7	5.6	7.3	8.8	11.2	12.3
17 years	69	225	9.0	5.98	0.69	5.2	5.5	6.6	7.6	9.6	11.9	20.7
Female												
12 years	88	272	10.4	6.69	0.91	4.6	5.3	6.6	8.4	11.8	20.5	24.6
13 years	91	275	10.5	6.40	0.51	5.2	5.7	7.0	8.6	11.6	18.7	30.0
14 years	101	266	11.3	6.25	0.49	5.7	6.4	7.5	9.5	13.6	18.1	25.1
15 years	73	235	11.9	6.04	0.52	6.2	6.7	8.4	10.4	13.4	21.5	26.0
16 years	93	243	13.8	8.72	1.56	6.1	7.1	8.3	10.5	16.4	26.6	32.8
17 years	74	237	13.4	7.27	1.05	6.9	7.3	8.3	12.3	16.0	22.1	30.5

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

Table 9. Midaxillary skinfold of youths by race, sex, and age at last birthday: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Race, sex, and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile 5th	10th	25th	50th	75th	90th	95th
			In millimeters									
WHITE												
Male												
12 years	540	1,747	6.5	5.01	0.22	3.0	3.2	3.8	4.8	6.8	14.2	19.6
13 years	542	1,729	6.8	5.57	0.20	3.2	3.3	4.1	5.0	7.1	13.8	19.5
14 years	526	1,682	6.9	5.92	0.33	3.2	3.5	4.2	5.2	7.1	14.3	19.8
15 years	525	1,646	7.2	5.84	0.26	3.4	3.8	4.4	5.5	7.6	13.4	19.7
16 years	496	1,594	7.0	5.01	0.28	3.5	4.0	4.5	5.6	7.5	13.2	18.3
17 years	416	1,525	7.8	5.65	0.34	3.6	4.1	4.6	5.8	8.3	15.1	22.4
Female												
12 years	454	1,681	8.6	5.91	0.34	3.6	4.2	5.1	6.6	10.6	16.8	23.5
13 years	490	1,667	9.4	6.33	0.36	4.0	4.5	5.7	7.5	11.5	18.2	23.3
14 years	484	1,633	10.3	6.28	0.23	4.4	5.1	6.4	8.4	12.8	20.1	23.2
15 years	424	1,590	11.1	7.13	0.39	4.6	5.2	6.5	8.7	13.4	22.5	27.4
16 years	441	1,542	11.4	7.06	0.38	4.8	5.6	6.9	9.5	13.7	21.6	28.2
17 years	393	1,502	11.1	7.11	0.52	4.6	5.4	6.7	8.8	13.8	21.1	26.2
NEGRO												
Male												
12 years	101	280	4.9	3.24	0.36	3.1	3.2	3.5	4.2	5.1	7.4	13.2
13 years	80	262	5.7	4.39	0.44	3.0	3.2	3.7	4.7	5.8	12.2	15.2
14 years	88	256	5.3	4.02	0.54	2.8	3.2	4.0	4.6	5.5	8.2	10.4
15 years	84	241	5.1	2.38	0.19	3.2	3.5	4.2	4.8	5.7	7.2	10.5
16 years	57	231	5.6	2.98	0.34	3.2	3.5	4.3	5.4	6.6	7.9	9.6
17 years	69	225	6.6	6.06	0.72	3.5	4.0	4.3	4.8	6.7	8.9	18.6
Female												
12 years	88	272	8.8	6.02	0.73	3.7	4.3	5.4	7.1	9.8	17.3	22.5
13 years	91	275	8.6	6.03	0.56	3.5	4.2	5.4	6.7	9.8	18.3	23.8
14 years	101	266	9.4	5.39	0.36	4.1	4.5	6.2	8.3	12.0	16.7	21.1
15 years	73	235	9.6	6.02	0.48	4.4	4.8	6.1	7.6	11.4	19.2	23.4
16 years	93	243	10.0	6.02	0.91	4.5	5.0	6.1	8.2	11.7	21.4	23.5
17 years	74	237	10.1	5.53	0.64	5.0	5.3	6.2	9.1	13.7	18.0	21.3

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

Table 10. Suprailiac skinfold of youths by race, sex, and age at last birthday: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Race, sex, and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In millimeters									
WHITE												
Male												
12 years	538	1,744	12.3	9.25	0.32	3.8	4.5	5.9	9.1	16.5	27.1	31.8
13 years	542	1,729	12.6	9.63	0.40	4.2	4.8	6.1	9.1	16.2	27.8	34.4
14 years	527	1,686	12.6	9.49	0.48	4.3	5.0	6.5	9.4	15.6	27.5	33.6
15 years	525	1,646	13.2	9.28	0.38	5.1	5.6	7.2	10.1	15.7	27.6	34.2
16 years	495	1,592	13.2	8.75	0.52	5.1	5.7	7.2	10.3	16.8	25.9	32.8
17 years	415	1,520	14.4	9.92	0.64	5.2	5.8	7.6	11.1	18.3	30.2	38.3
Female												
12 years	453	1,677	13.9	8.20	0.48	4.9	5.6	7.7	12.3	18.7	25.5	30.8
13 years	490	1,667	14.9	8.06	0.41	5.5	6.7	9.1	13.4	19.3	26.1	32.0
14 years	484	1.633	15.7	7.78	0.38	6.3	7.4	10.2	14.2	20.5	26.8	31.3
15 years	424	1,590	16.7	8.51	0.56	6.6	7.6	10.5	14.9	22.1	29.7	34.5
16 years	441	1,542	16.2	7.95	0.51	7.0	8.2	10.8	15.1	20.2	27.2	31.9
17 years	392	1,499	16.1	8.66	0.57	6.2	7.4	10.2	14.1	20.9	28.6	33.0
NEGRO												
Male												
12 years	100	278	8.3	6.86	0.90	3.5	4.1	4.9	6.2	8.8	18.2	23.5
13 years	80	262	9.6	8.15	1.00	3.3	3.8	5.0	6.6	11.8	22.4	33.3
14 years	88	256	9.0	8.22	1.16	3.6	4.1	5.2	6.8	9.5	15.6	26.1
15 years	84	241	8.1	5.49	0.59	4.1	4.3	5.2	6.5	10.0	13.4	23.4
16 years	57	231	9.1	5.75	0.50	4.1	4.5	5.5	7.9	10.8	15.4	19.6
17 years	69	225	9.9	8.27	0.82	4.3	4.8	5.5	7.1	10.5	19.8	26.6
Female												
12 years	88	272	13.6	9.27	1.23	4.0	5.2	7.5	11.3	18.7	25.8	32.3
13 years	91	275	13.2	9.09	0.90	5.0	5.6	6.8	10.9	17.0	27.7	36.6
14 years	101	266	14.4	7.48	0.73	4.7	6.3	8.6	13.7	18.7	25.4	30.2
15 years	73	235	14.3	7.50	0.72	5.5	6.4	8.8	13.2	18.2	23.8	29.5
16 years	93	243	15.9	9.20	1.60	6.0	6.9	9.3	12.6	21.3	30.8	35.5
17 years	74	237	14.6	8.42	0.98	5.5	7.2	9.5	12.8	17.7	24.7	30.4

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

Table 11. Medial calf skinfold of youths by race, sex, and age at last birthday: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Race, sex, and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile 5th	10th	25th	50th	75th	90th	95th
			In millimeters									
WHITE												
Male												
12 years	537	1,738	12.5	6.90	0.28	5.2	5.8	7.7	11.1	16.2	21.9	26.8
13 years	537	1,714	12.8	6.98	0.37	5.5	6.3	8.2	11.3	16.1	22.8	27.5
14 years	522	1,672	11.8	7.01	0.38	5.1	5.6	7.1	10.2	14.9	20.7	25.4
15 years	522	1,637	11.2	6.57	0.34	4.7	5.5	7.2	10.0	13.5	20.3	25.1
16 years	493	1,586	10.4	5.98	0.32	4.2	5.0	6.5	8.7	13.3	19.6	22.6
17 years	415	1,521	10.3	6.15	0.32	4.2	4.7	6.3	8.8	12.5	19.1	23.0
Female												
12 years	450	1,667	15.6	6.77	0.32	7.5	8.6	11.3	14.4	19.6	24.7	30.4
13 years	487	1,657	17.1	7.07	0.36	7.7	9.5	12.3	15.9	21.7	26.5	31.4
14 years	478	1,610	18.2	7.01	0.40	9.2	10.5	13.1	17.3	23.1	28.4	30.9
15 years	420	1,576	19.4	7.78	0.57	9.2	11.0	14.5	18.4	23.4	30.2	35.6
16 years	435	1,521	19.5	7.02	0.42	10.3	11.6	15.0	19.2	23.8	28.8	31.6
17 years	389	1,487	20.5	7.72	0.53	10.2	11.7	15.5	20.0	24.7	31.2	34.8
NEGRO												
Male												
12 years	100	278	8.5	5.00	0.69	3.6	4.2	5.2	7.6	10.6	16.1	19.8
13 years	79	251	8.9	6.79	0.82	3.6	4.2	5.2	7.1	10.2	17.4	24.5
14 years	87	253	8.2	5.99	0.80	4.0	4.3	5.2	7.1	9.6	12.4	21.2
15 years	83	238	7.0	3.48	0.36	4.2	4.5	5.3	6.3	7.8	10.7	14.8
16 years	57	231	7.1	3.38	0.43	3.5	4.1	5.1	6.5	9.2	11.7	13.2
17 years	69	225	7.7	5.91	0.70	3.3	3.6	4.9	6.2	8.4	16.2	18.8
Female												
12 years	82	253	13.1	6.42	0.84	6.5	7.5	9.7	11.4	15.8	20.8	25.5
13 years	91	275	14.0	7.25	0.58	6.3	7.2	9.3	11.9	17.0	24.6	30.6
14 years	100	263	15.2	6.41	0.47	7.1	7.8	10.4	14.5	20.2	25.3	27.1
15 years	72	233	14.4	6.12	0.56	7.4	8.5	10.6	13.8	17.1	24.2	27.8
16 years	93	243	16.4	8.27	1.52	7.6	9.1	11.0	14.3	19.7	25.9	38.5
17 years	70	219	14.2	4.97	0.68	7.9	8.5	11.0	13.4	17.9	21.2	22.7

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

Table 12. Skewness coefficients (difference between the 50th and 95th percentile divided by the difference between the 5th and 50th percentile) by skinfold site, race, sex, and age at last birthday of youths: United States, 1966-70

Sex and age	Triceps skinfold		Subscapular skinfold		Midaxillary skinfold		Suprailiac skinfold		Medial calf skinfold	
	White	Negro	White	Negro	White	Negro	White	Negro	White	Negro
Male										
6 years	1.67	1.33	3.00	2.50	2.00	2.00	-	-	-	-
7 years	2.17	2.00	2.33	3.00	4.00	1.33	-	-	-	-
8 years	3.00	2.60	4.66	1.00	6.00	2.00	-	-	-	-
9 years	3.00	3.00	6.67	1.50	11.00	3.00	-	-	-	-
10 years	2.63	2.00	6.67	4.66	11.00	6.00	-	-	-	-
11 years	2.67	3.67	5.75	6.00	6.50	9.00	-	-	-	-
12 years	2.98	4.49	7.30	8.12	8.23	7.75	4.30	6.46	2.67	3.06
13 years	2.85	4.97	7.55	5.35	7.74	6.23	5.18	7.93	2.82	4.99
14 years	3.45	4.58	5.93	4.10	7.52	3.34	4.81	6.03	2.99	4.64
15 years	3.88	3.31	6.07	2.69	6.92	3.78	4.83	6.84	2.84	4.10
16 years	3.87	2.32	6.15	1.70	6.09	1.88	4.29	3.12	3.14	2.23
17 years	3.62	5.17	5.37	5.45	7.63	10.33	4.59	6.88	3.05	4.29
Female										
6 years	1.50	3.50	3.67	2.00	6.00	3.00	-	-	-	-
7 years	2.29	3.40	7.00	2.50	4.33	4.00	-	-	-	-
8 years	1.80	4.00	5.00	8.00	5.00	4.67	-	-	-	-
9 years	2.44	2.50	6.50	4.00	5.00	3.50	-	-	-	-
10 years	1.83	2.80	7.00	3.00	4.67	5.50	-	-	-	-
11 years	2.00	2.50	4.33	4.33	5.20	5.50	-	-	-	-
12 years	2.21	3.27	5.04	4.31	5.60	4.54	2.47	2.89	2.32	2.90
13 years	2.07	4.54	4.74	6.30	4.54	5.29	2.35	4.39	1.92	3.34
14 years	1.81	1.73	3.90	4.21	3.68	3.07	2.17	1.83	1.69	1.70
15 years	1.93	2.29	4.38	3.81	4.52	4.86	2.37	2.14	1.87	2.17
16 years	1.66	3.00	4.12	5.06	4.00	4.10	2.08	3.51	1.64	3.61
17 years	1.71	1.97	3.93	3.34	4.16	2.97	2.39	2.38	1.78	1.69

Table 13. Sample size and correlation coefficients for all possible pairs of skinfolds of youths by race and sex: United States, 1966-70

Race and sex	Sample size	Skinfold pair									
		Triceps-calf	Subscap-ular-calf	Midaxil-lary-calf	Supra-iliac-calf	Triceps-subscap-ular	Triceps-midaxil-lary	Triceps-supra-iliac	Subscap-ular-midaxil-lary	Subscap-ular-supra-iliac	Midaxil-lary-supra-iliac
Total[1]											
Both sexes-----	6,685	.8688	.7351	.7437	.7256	.8063	.8002	.7790	.9114	.8371	.8523
Male---------------	3,513	.8745	.7497	.7537	.7920	.8088	.7951	.8380	.9100	.8691	.8709
Female-------------	3,172	.8149	.6890	.7004	.6850	.7835	.7797	.7540	.9017	.8296	.8527
White											
Both sexes-----	5,670	.8697	.7346	.7388	.7127	.8068	.8008	.7724	.9123	.8349	.8483
Male---------------	3,020	.8701	.7454	.7454	.7817	.8077	.7910	.8336	.9081	.8703	.8683
Female-------------	2,650	.8185	.6956	.7005	.6802	.7893	.7879	.7545	.9054	.8289	.8524
Negro											
Both sexes-----	982	.8584	.7794	.7824	.7883	.8179	.7960	.8059	.9138	.8666	.8812
Male---------------	474	.8922	.8065	.8135	.8301	.8173	.8144	.8464	.9309	.8829	.8901
Female-------------	508	.7853	.7224	.7180	.7280	.7816	.7404	.7490	.8904	.8426	.8627

[1]Includes data for "other races," which are not shown separately.

Table 14. Sample size and correlation coefficients for all possible pairs of skinfolds of youths by race, sex, and age at last birthday: United States, 1966-70

Race, sex, and age	Sample size	Skinfold pair									
		Triceps-calf	Subscap-ular-calf	Midaxil-lary-calf	Supra-iliac-calf	Triceps-subscap-ular	Triceps-midaxil-lary	Triceps-supra-iliac	Subscap-ular-midaxil-lary	Subscap-ular-supra-iliac	Midaxil-lary-supra-iliac
TOTAL[1]											
Male											
12 years	636	.8786	.7651	.7836	.8479	.8258	.8285	.8652	.9332	.8533	.8857
13 years	620	.8801	.7847	.7757	.8152	.8511	.8177	.8780	.9100	.8840	.8646
14 years	611	.8666	.7598	.7740	.7966	.8206	.8328	.8636	.9156	.8794	.8879
15 years	609	.8874	.7941	.7487	.8306	.8345	.7714	.8714	.8946	.8765	.8322
16 years	551	.8722	.7288	.7510	.7527	.8232	.8271	.8126	.9017	.8575	.8778
17 years	485	.8502	.7939	.7992	.7959	.8260	.8073	.8167	.9226	.8701	.8894
Female											
12 years	532	.8286	.7422	.7624	.7492	.8125	.8117	.8015	.9123	.8459	.8530
13 years	579	.8568	.7479	.7497	.7539	.8161	.8112	.7993	.9074	.8654	.8901
14 years	579	.7848	.6218	.6584	.6608	.7189	.7406	.7261	.8926	.8198	.8555
15 years	495	.8194	.6942	.7053	.6965	.7874	.8002	.7725	.9117	.8281	.8558
16 years	529	.7975	.6623	.6570	.6534	.7723	.7555	.7387	.8849	.8286	.8377
17 years	458	.7556	.6142	.6359	.5758	.7613	.7398	.6916	.8953	.7978	.8209
WHITE											
Male											
12 years	535	.8752	.7581	.7741	.8394	.8228	.8244	.8575	.9316	.8513	.8807
13 years	537	.8716	.7871	.7696	.8092	.8490	.8101	.8761	.9054	.8833	.8590
14 years	521	.8605	.7495	.7626	.7820	.8165	.8325	.8568	.9171	.8797	.8900
15 years	522	.8885	.7992	.7463	.8307	.8413	.7709	.8748	.8952	.8779	.8312
16 years	491	.8703	.7300	.7482	.7467	.8241	.8250	.8106	.9034	.8608	.8770
17 years	413	.8400	.7828	.7872	.7810	.8285	.8001	.8118	.9192	.8814	.8919
Female											
12 years	446	.8437	.7485	.7695	.7568	.8155	.8256	.8111	.9198	.8508	.8628
13 years	487	.8449	.7400	.7408	.7448	.8152	.8097	.7869	.9025	.8618	.8873
14 years	478	.8170	.6370	.6687	.6592	.7539	.7786	.7538	.8937	.8243	.8640
15 years	418	.8189	.7073	.7099	.6895	.7978	.8053	.7614	.9134	.8259	.8536
16 years	434	.7804	.6489	.6383	.6403	.7636	.7511	.7375	.9008	.8283	.8351
17 years	387	.7544	.6348	.6416	.5756	.7577	.7404	.6901	.8972	.7898	.8118
NEGRO											
Male											
12 years	99	.8725	.8198	.8050	.8419	.8978	.8984	.9019	.9282	.9019	.9343
13 years	79	.9224	.8346	.8801	.8533	.9124	.9167	.8868	.9671	.9023	.9326
14 years	87	.8992	.8757	.8928	.8910	.8630	.8516	.8991	.9407	.9024	.8733
15 years	83	.8089	.6929	.7342	.7147	.6638	.7106	.7499	.8747	.8723	.8670
16 years	57	.8887	.7807	.8180	.7971	.8346	.8540	.8120	.8643	.8212	.8880
17 years	69	.9104	.8979	.8746	.8706	.8380	.8503	.8436	.9458	.8873	.9111
Female											
12 years	82	.7164	.7419	.7380	.7039	.8242	.7296	.7481	.8581	.8270	.7949
13 years	91	.9081	.8431	.8186	.8008	.8604	.8357	.8464	.9397	.9039	.9110
14 years	100	.6402	.5766	.5951	.6643	.5736	.5632	.5976	.8934	.8001	.8042
15 years	72	.8201	.6693	.6917	.7355	.7353	.7573	.8352	.9096	.8549	.8687
16 years	93	.8516	.8118	.7715	.7551	.8566	.7958	.7662	.8576	.8369	.8897
17 years	70	.7138	.6893	.6904	.6689	.8509	.7520	.7033	.9039	.8475	.8960

[1]Includes data for "other races," which are not shown separately.

Table 15. Rankings of correlation coefficients for all possible pairs of skinfolds of youths with each race, sex, and age group: United States, 1966-70

Race, sex, and age	Sample size	Skinfold pair: Triceps-calf	Subscapular-calf	Midaxillary-calf	Supra-iliac-calf	Triceps-subscapular	Triceps-midaxillary	Triceps-supra-iliac	Subscapular-midaxillary	Subscapular-supra-iliac	Midaxillary-supra-iliac
TOTAL[1]											
Male											
12 years	636	8	1	2	5	3	4	7	10	6	9
13 years	620	8	2	1	3	5	4	7	10	9	6
14 years	611	7	1	2	3	4	5	6	10	8	9
15 years	609	9	3	1	4	6	2	7	10	8	5
16 years	551	8	1	2	3	5	6	4	10	7	9
17 years	485	7	1	3	2	6	4	5	10	8	9
Female											
12 years	532	7	1	3	2	6	5	4	10	8	9
13 years	579	7	1	2	3	6	5	4	10	8	9
14 years	579	7	1	2	3	4	6	5	10	8	9
15 years	495	7	1	3	2	5	6	4	10	8	9
16 years	529	7	3	2	1	6	5	4	10	8	9
17 years	458	6	2	3	1	7	5	4	10	8	9
WHITE											
Male											
12 years	535	8	1	2	5	3	4	7	10	6	9
13 years	537	7	2	1	3	5	4	8	10	9	6
14 years	521	7	1	2	3	4	5	6	10	8	9
15 years	522	9	3	1	4	6	2	7	10	8	5
16 years	491	8	1	3	2	5	6	4	10	7	9
17 years	413	7	2	3	1	6	4	5	10	8	9
Female											
12 years	446	7	1	3	2	5	6	4	10	8	9
13 years	487	7	1	2	3	6	5	4	10	8	9
14 years	478	7	1	3	2	5	6	4	10	8	9
15 years	418	7	2	3	1	5	6	4	10	8	9
16 years	434	7	3	1	2	6	5	4	10	8	9
17 years	387	6	2	3	1	7	5	4	10	8	9
NEGRO											
Male											
12 years	99	4	2	1	3	5	6	7½	9	7½	10
13 years	79	8	1	3	2	6	7	4	10	5	9
14 years	87	8	4	6	5	2	1	7	10	9	3
15 years	83	7	2	5	4	1	3	6	10	9	8
16 years	57	10	1	4	2	6	7	3	10	5	9
17 years	69	8	7	5	4	1	3	2	10	6	9
Female											
12 years	82	2	5	4	1	8	3	6	10	9	7
13 years	91	8	4	2	1	6	3	5	10	7	9
14 years	100	6	3	4	7	2	1	5	10	8	9
15 years	72	6	1	2	4	3	5	7	10	8	9
16 years	93	7	5	3	1	8	4	2	9	6	10
17 years	70	5	2	3	1	8	6	4	10	7	9

[1]Includes data for "other races," which are not shown separately.

Table 16. Triceps skinfold of youths by geographic region, sex, and age at last birthday: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Geographic region, sex, and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In millimeters									
NORTHEAST												
Male												
12 years	173	474	11.5	5.73	0.65	5.5	6.2	7.5	10.3	14.1	20.7	25.3
13 years	162	475	10.8	6.41	0.38	4.4	5.2	6.8	9.5	13.4	20.6	25.1
14 years	156	466	10.0	6.03	0.60	4.2	4.7	6.4	8.4	12.6	18.2	22.4
15 years	137	393	8.9	5.29	0.44	4.3	4.8	6.0	7.3	10.7	16.3	21.4
16 years	124	373	9.5	5.48	0.59	4.5	5.1	6.0	7.6	12.2	17.2	23.0
17 years	118	364	10.6	6.87	0.57	4.5	5.1	6.4	8.8	12.4	21.7	28.2
Female												
12 years	135	469	13.5	5.95	0.75	5.9	7.0	9.2	12.5	16.8	23.1	25.3
13 years	145	430	13.8	6.18	0.54	6.6	7.5	9.0	12.7	18.1	23.4	25.6
14 years	139	411	15.1	5.63	0.54	7.5	9.0	11.1	15.2	18.3	23.3	25.7
15 years	121	398	15.3	6.97	0.43	7.2	8.3	11.3	14.2	18.4	23.8	30.2
16 years	125	390	17.0	6.14	0.52	7.6	8.7	12.9	17.3	21.1	24.8	29.0
17 years	106	388	16.9	6.39	0.54	7.9	10.1	12.6	16.4	22.0	24.7	27.4
MIDWEST												
Male												
12 years	167	569	11.1	6.58	0.54	5.1	5.5	7.0	9.6	13.6	20.6	24.8
13 years	163	582	10.7	5.91	0.66	5.0	5.4	6.7	8.8	14.1	19.3	22.8
14 years	162	538	10.2	5.68	0.46	4.4	5.2	6.5	8.8	13.2	17.4	23.4
15 years	162	571	9.3	5.39	0.60	4.5	5.1	6.0	7.9	10.8	16.5	22.4
16 years	152	528	9.2	5.13	0.59	4.4	5.1	6.1	7.6	11.9	16.5	20.4
17 years	116	474	8.6	5.41	0.53	3.6	4.3	5.4	7.2	10.3	15.4	19.7
Female												
12 years	150	586	13.7	5.76	0.58	7.1	7.8	9.5	12.6	16.9	23.6	25.6
13 years	157	588	14.0	6.22	0.74	6.1	7.0	9.3	13.1	17.6	24.4	25.5
14 years	148	530	15.6	6.37	0.52	7.5	9.1	11.4	14.4	20.0	25.9	28.6
15 years	108	483	16.4	6.66	0.90	8.1	8.8	11.9	15.2	20.6	26.5	29.5
16 years	140	500	17.4	6.90	0.88	8.5	10.6	12.7	15.9	21.8	27.3	31.3
17 years	132	536	16.8	6.24	1.06	9.1	10.5	12.2	16.2	20.5	27.2	29.8
SOUTH												
Male												
12 years	149	446	10.0	5.31	0.45	4.4	5.1	6.5	9.0	13.1	17.9	22.3
13 years	149	459	10.0	5.63	0.47	4.1	4.8	6.3	8.8	11.7	18.5	22.5
14 years	149	454	8.3	4.40	0.50	4.2	4.6	5.6	7.2	9.4	15.4	19.4
15 years	163	460	8.7	5.34	0.46	4.0	4.4	5.4	7.3	10.6	15.6	19.8
16 years	149	481	8.7	4.81	0.38	3.8	4.5	5.6	7.5	11.1	15.2	19.3
17 years	130	430	8.7	5.09	0.40	4.2	4.8	5.4	7.2	11.1	14.4	21.3
Female												
12 years	128	430	13.1	6.53	0.46	6.0	6.7	8.6	11.4	17.1	21.6	25.8
13 years	142	435	13.2	6.51	0.41	6.4	7.2	8.8	11.6	16.7	23.2	27.0
14 years	161	482	14.6	6.72	0.37	6.4	8.1	10.3	13.6	18.3	22.7	26.8
15 years	138	474	16.7	6.81	0.78	8.2	9.4	11.6	15.9	20.8	25.8	31.7
16 years	126	386	15.8	8.20	1.28	7.5	9.1	10.6	13.5	19.5	25.4	31.3
17 years	117	410	15.9	5.58	0.32	8.1	9.4	12.1	15.7	18.7	23.3	26.6
WEST												
Male												
12 years	154	543	10.0	5.32	0.47	5.0	5.4	6.6	8.7	12.2	18.5	21.5
13 years	152	490	10.3	5.35	0.44	4.6	5.4	6.8	9.2	12.8	19.1	21.9
14 years	150	489	9.3	5.86	0.64	4.1	4.5	5.7	7.6	11.6	17.4	21.6
15 years	151	475	8.8	4.31	0.51	4.3	4.7	6.1	7.8	10.7	14.9	19.4
16 years	130	451	8.1	4.23	0.50	3.8	4.4	5.5	7.2	10.2	14.7	18.3
17 years	125	496	8.4	4.16	0.52	4.2	4.5	5.4	7.1	11.1	15.3	16.8
Female												
12 years	134	485	11.0	4.54	0.58	5.6	6.4	8.1	10.5	13.5	17.4	20.7
13 years	138	493	13.1	5.27	0.57	6.5	7.5	9.7	12.3	15.7	20.5	25.0
14 years	138	478	14.0	5.51	0.71	6.6	7.8	9.9	12.9	18.5	22.6	23.9
15 years	135	493	14.9	5.80	0.70	6.4	7.8	11.6	14.4	18.4	23.1	25.6
16 years	144	511	15.8	6.26	0.41	7.5	9.2	11.6	15.4	19.7	24.5	26.4
17 years	113	410	16.1	6.63	1.29	7.6	8.8	10.6	15.3	21.0	25.4	27.7

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

Table 17. Subscapular skinfold of youths by geographic region, sex, and age at last birthday: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Geographic region, sex, and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In millimeters									
NORTHEAST												
Male												
12 years	173	474	8.1	5.71	0.45	4.1	4.3	5.1	6.2	9.1	14.8	21.6
13 years	162	475	8.4	6.49	0.37	4.1	4.4	5.2	6.4	8.4	17.3	21.9
14 years	156	466	8.3	6.10	0.60	4.3	4.6	5.4	6.7	7.9	15.1	22.6
15 years	137	393	8.6	5.73	0.34	4.5	5.0	5.8	6.8	9.1	15.4	23.9
16 years	124	373	8.6	5.12	0.39	5.0	5.3	6.1	7.2	9.3	15.5	21.2
17 years	117	361	10.3	5.78	0.45	5.4	6.0	7.0	8.4	11.4	18.6	25.0
Female												
12 years	135	469	10.4	5.82	0.34	4.8	5.2	6.2	8.7	13.3	19.1	23.1
13 years	145	430	11.2	6.75	0.49	5.1	5.5	7.0	8.9	13.5	21.2	26.9
14 years	139	411	11.5	6.12	0.95	5.6	6.3	7.6	9.8	13.7	19.5	25.7
15 years	120	394	12.4	6.97	0.72	6.0	6.5	7.7	10.1	15.2	21.8	29.3
16 years	125	390	13.3	6.48	0.77	6.6	7.2	9.0	12.2	16.6	22.3	25.9
17 years	106	388	13.1	6.88	0.53	6.5	7.2	8.4	11.5	16.6	22.8	31.6
MIDWEST												
Male												
12 years	167	569	7.6	5.80	0.32	3.6	4.1	4.8	5.7	7.6	15.9	21.9
13 years	163	582	8.0	6.29	0.53	4.2	4.4	5.2	6.2	8.6	13.4	20.2
14 years	162	538	7.9	4.96	0.50	4.4	4.9	5.4	6.6	8.8	13.5	16.8
15 years	162	571	8.6	6.06	0.42	4.6	5.1	5.7	6.8	8.6	15.4	21.5
16 years	152	528	8.7	4.89	0.59	5.2	5.5	6.3	7.3	9.8	15.4	20.3
17 years	116	474	9.2	5.58	0.60	4.8	5.4	6.4	7.7	10.4	15.9	19.6
Female												
12 years	149	583	10.2	6.16	0.71	4.5	5.1	6.0	7.9	12.7	21.1	24.3
13 years	157	588	11.2	7.28	0.83	5.0	5.3	6.5	8.8	13.2	22.9	27.7
14 years	148	530	12.2	6.79	0.70	6.3	6.7	8.0	10.3	14.9	23.2	29.1
15 years	108	483	12.6	7.56	0.71	6.2	6.5	7.7	10.4	15.4	24.8	30.2
16 years	140	500	13.6	7.53	0.61	6.8	7.3	8.5	10.8	15.9	25.4	31.5
17 years	132	536	13.6	8.12	1.27	6.2	6.5	8.1	11.4	18.5	24.4	29.7
SOUTH												
Male												
12 years	149	446	6.6	4.41	0.36	3.7	4.2	4.7	5.6	6.8	10.6	18.1
13 years	149	459	7.8	6.04	0.33	4.0	4.3	5.1	6.0	7.9	16.4	24.4
14 years	150	456	7.6	4.78	0.51	3.8	4.4	5.3	6.4	7.7	13.7	18.3
15 years	163	460	7.8	5.00	0.30	4.4	4.8	5.5	6.6	8.8	12.0	16.5
16 years	149	481	8.4	5.19	0.42	5.0	5.2	5.9	7.3	9.2	13.2	20.7
17 years	129	427	8.8	4.55	0.38	5.0	5.3	6.4	7.6	10.3	14.3	21.0
Female												
12 years	128	430	10.3	7.91	0.60	4.4	4.8	6.1	7.7	11.3	20.8	27.8
13 years	142	435	10.6	6.84	0.47	4.9	5.4	6.7	8.4	12.2	20.8	25.4
14 years	161	482	11.6	7.94	0.23	5.1	5.6	7.1	9.3	13.6	20.8	26.5
15 years	138	474	13.2	8.08	0.56	5.8	6.5	8.0	10.4	15.3	27.3	31.0
16 years	126	386	12.6	9.14	1.12	5.5	6.1	7.3	9.4	14.8	24.6	32.3
17 years	118	412	12.7	7.34	0.38	5.8	6.5	8.3	11.4	15.1	21.1	28.6
WEST												
Male												
12 years	154	543	7.0	5.45	0.79	3.5	4.0	4.5	5.5	7.3	11.6	17.7
13 years	152	490	8.0	5.87	0.57	3.9	4.2	4.8	5.9	8.8	16.1	21.8
14 years	150	489	8.5	6.46	0.67	3.9	4.4	5.3	6.3	9.2	14.7	25.5
15 years	151	475	8.2	4.62	0.46	4.8	5.3	6.2	7.2	8.8	12.6	18.0
16 years	131	453	8.0	4.47	0.37	4.6	5.1	6.0	7.2	8.7	13.0	17.0
17 years	125	496	9.3	4.67	0.66	5.3	5.8	6.6	7.6	10.5	17.4	20.5
Female												
12 years	134	485	8.1	4.42	0.51	4.3	4.8	5.7	6.9	9.1	14.2	17.7
13 years	138	493	9.9	6.28	0.63	4.7	5.2	6.2	7.9	10.9	19.2	23.2
14 years	138	478	10.8	5.64	0.50	5.3	6.1	7.2	9.3	13.5	17.6	20.9
15 years	135	493	11.5	6.03	0.68	5.4	6.2	7.7	10.2	14.4	20.1	24.7
16 years	145	513	12.7	6.98	0.78	6.2	6.8	7.8	10.9	14.9	24.6	29.2
17 years	113	410	13.5	8.25	1.38	6.4	7.0	7.9	11.1	17.5	23.6	35.1

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

Table 18. Midaxillary skinfold of youths by geographic region, sex, and age at last birthday: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Geographic region, sex, and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile 5th	10th	25th	50th	75th	90th	95th
			In millimeters									
NORTHEAST												
Male												
12 years	173	474	7.1	5.38	0.54	3.2	3.4	4.1	5.2	7.6	15.9	21.5
13 years	162	475	7.2	6.13	0.33	3.2	3.5	4.2	5.2	7.5	15.2	20.4
14 years	156	466	7.2	7.00	0.88	3.3	3.6	4.3	5.2	6.6	14.8	25.1
15 years	137	393	7.4	6.27	0.41	3.3	3.6	4.4	5.5	7.6	16.3	22.9
16 years	124	373	7.0	5.10	0.37	3.6	4.1	4.6	5.5	7.3	13.5	21.2
17 years	117	361	8.6	6.24	0.59	3.6	4.1	4.8	6.4	10.5	17.5	22.7
Female												
12 years	134	466	9.3	5.54	0.27	4.1	4.3	5.2	7.6	12.4	17.1	19.7
13 years	145	430	9.9	6.24	0.35	4.1	4.8	6.1	7.8	12.1	18.5	27.1
14 years	139	411	10.1	5.64	0.81	4.4	4.9	6.5	9.2	12.4	18.4	21.7
15 years	120	394	10.4	6.57	0.41	4.6	5.2	6.3	8.7	12.2	20.5	26.7
16 years	125	390	11.6	5.74	0.53	5.5	6.2	7.8	10.4	14.4	18.1	23.1
17 years	106	388	10.7	6.31	0.60	4.8	5.9	7.1	9.2	12.9	16.9	21.8
MIDWEST												
Male												
12 years	167	569	6.5	4.91	0.21	3.0	3.2	3.8	4.8	7.1	15.1	19.8
13 years	163	582	6.5	5.39	0.39	3.2	3.4	4.1	5.0	7.0	10.8	18.3
14 years	162	539	6.5	5.03	0.43	3.3	3.5	4.3	5.3	7.0	11.4	17.4
15 years	162	571	7.2	5.90	0.46	3.6	4.1	4.5	5.4	7.5	13.7	20.5
16 years	152	529	7.3	5.39	0.65	3.5	4.0	4.7	5.6	7.6	13.5	19.5
17 years	116	474	7.4	5.88	0.56	3.4	3.8	4.6	5.7	7.6	13.5	21.5
Female												
12 years	150	586	9.3	5.90	0.58	3.8	4.5	5.5	7.1	12.1	19.3	24.3
13 years	157	588	9.8	6.84	0.78	4.1	4.5	5.7	7.6	11.9	19.8	23.6
14 years	148	530	11.0	6.51	0.57	5.2	5.9	6.8	8.6	13.6	22.2	25.0
15 years	108	483	11.2	6.99	0.75	4.8	5.4	6.6	8.6	13.8	20.9	27.5
16 years	140	500	12.2	8.08	0.59	5.1	5.7	7.1	9.6	14.5	28.3	31.1
17 years	132	536	11.6	7.69	1.25	4.8	5.3	6.5	9.0	15.5	22.1	24.9
SOUTH												
Male												
12 years	149	446	5.7	4.45	0.34	3.1	3.2	3.7	4.6	6.1	10.4	17.2
13 years	149	459	6.2	4.96	0.31	3.0	3.3	4.0	4.8	6.3	13.4	18.7
14 years	150	456	6.1	4.64	0.45	3.1	3.3	4.1	4.7	6.1	11.7	14.7
15 years	163	460	6.4	4.84	0.28	3.3	3.6	4.3	5.1	6.7	11.0	16.7
16 years	149	481	6.7	4.40	0.31	3.4	3.8	4.5	5.6	7.3	11.7	15.6
17 years	130	430	7.2	5.38	0.52	3.5	4.0	4.5	5.4	7.6	13.7	18.8
Female												
12 years	128	430	8.5	7.34	0.53	3.3	3.9	4.7	6.4	8.9	23.1	25.5
13 years	142	435	9.0	6.20	0.43	4.1	4.4	5.5	6.9	10.7	18.0	23.0
14 years	161	482	9.8	6.66	0.17	3.8	4.4	5.6	7.6	12.1	17.8	23.8
15 years	139	476	11.6	7.96	0.79	4.5	5.2	6.5	8.4	15.2	24.4	29.6
16 years	126	386	10.0	6.75	0.58	4.1	4.6	6.2	7.8	11.9	18.8	25.1
17 years	118	412	10.0	5.55	0.27	4.5	5.2	6.6	8.8	11.8	15.8	24.2
WEST												
Male												
12 years	154	543	5.9	4.85	0.62	2.8	3.1	3.6	4.5	6.2	10.9	18.1
13 years	152	490	6.6	5.10	0.44	3.1	3.3	3.9	4.9	7.1	13.3	19.7
14 years	149	486	7.1	5.92	0.58	3.1	3.3	4.1	4.9	7.5	14.6	22.2
15 years	151	475	6.9	5.06	0.56	3.4	3.8	4.4	5.4	7.4	12.0	17.2
16 years	131	453	6.3	4.19	0.49	3.3	3.6	4.3	5.4	7.0	10.6	14.1
17 years	125	496	7.4	5.32	0.86	4.0	4.2	4.6	5.6	7.5	15.7	22.6
Female												
12 years	134	485	7.2	4.44	0.43	3.4	4.0	4.7	5.9	8.0	14.0	17.9
13 years	138	493	8.5	5.57	0.44	3.5	4.2	5.4	7.1	10.5	14.6	21.2
14 years	138	478	9.8	5.61	0.52	4.3	4.8	6.2	8.1	12.2	18.8	21.1
15 years	135	493	10.2	6.21	0.75	4.3	4.8	6.3	8.5	12.6	19.4	25.2
16 years	145	513	10.9	6.52	0.76	4.9	5.4	6.7	9.1	12.5	20.8	25.4
17 years	113	410	11.3	7.49	1.34	4.7	5.3	6.4	8.4	14.9	22.1	27.0

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

Table 19. Suprailiac skinfold of youths by geographic region, sex, and age at last birthday: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Geographic region, sex, and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile 5th	10th	25th	50th	75th	90th	95th
			In millimeters									
NORTHEAST												
Male												
12 years	173	474	12.9	9.53	0.87	4.2	4.6	6.1	10.1	17.6	27.3	36.0
13 years	162	475	12.8	10.26	0.45	4.3	4.9	6.2	8.7	15.3	30.5	35.3
14 years	156	466	12.0	9.92	0.98	4.4	4.8	6.4	8.5	14.0	25.5	36.2
15 years	137	393	12.5	9.19	0.47	5.0	5.5	6.8	9.3	14.6	27.6	36.6
16 years	124	373	13.1	9.43	0.56	5.2	5.8	7.2	9.5	16.1	27.8	33.7
17 years	117	361	15.6	10.87	0.61	5.0	5.6	7.9	11.6	20.8	34.4	38.6
Female												
12 years	135	469	15.0	8.67	0.56	4.5	5.8	8.5	13.2	20.3	27.6	31.3
13 years	145	430	15.8	8.58	0.52	5.5	6.8	9.6	14.6	19.4	27.7	36.2
14 years	139	411	15.6	7.00	1.11	6.3	7.8	10.6	15.3	19.6	25.6	30.4
15 years	120	394	15.7	7.24	0.59	6.4	7.4	10.8	14.9	20.5	25.2	31.5
16 years	125	390	16.5	7.10	0.52	7.1	9.2	11.4	15.8	20.4	27.2	30.3
17 years	106	388	16.2	7.73	0.72	6.4	8.4	10.8	14.5	20.6	26.6	33.3
MIDWEST												
Male												
12 years	167	569	12.3	9.77	0.49	3.5	4.3	5.6	7.8	16.2	27.7	32.4
13 years	163	582	11.6	8.78	0.63	4.1	4.5	5.8	8.8	14.8	24.8	30.7
14 years	162	538	12.4	9.12	0.89	4.3	5.2	6.5	9.7	14.9	26.1	31.8
15 years	162	571	13.1	9.64	0.62	5.0	5.5	6.8	9.4	16.2	26.8	35.6
16 years	152	528	13.2	8.75	0.98	4.5	5.2	7.2	10.3	17.4	25.5	33.2
17 years	116	474	13.4	9.13	0.56	4.7	5.4	6.8	10.3	17.8	27.5	29.8
Female												
12 years	149	582	14.9	8.49	0.94	5.4	6.2	8.4	13.2	20.4	25.8	32.5
13 years	157	588	14.6	8.11	0.72	5.1	6.1	8.8	13.2	18.5	26.8	30.4
14 years	148	530	16.0	7.50	0.79	7.1	7.8	10.5	14.8	20.6	27.3	31.4
15 years	108	483	16.2	8.63	1.17	6.6	7.4	9.6	14.5	20.6	30.0	35.0
16 years	140	500	16.7	8.40	0.97	6.5	8.1	10.7	15.3	20.7	30.5	34.1
17 years	131	532	15.6	8.61	1.16	5.6	6.6	9.5	13.8	21.4	28.4	31.4
SOUTH												
Male												
12 years	149	446	10.5	8.09	0.59	3.6	4.3	5.6	7.9	12.6	20.8	28.2
13 years	149	459	11.7	9.48	0.85	3.6	4.4	5.8	8.5	14.2	26.2	33.8
14 years	150	456	11.0	8.60	0.78	4.1	4.5	5.7	7.8	12.4	26.2	30.4
15 years	163	460	11.3	8.79	0.73	4.3	4.7	6.2	8.1	12.4	25.4	30.2
16 years	148	479	12.0	8.48	0.93	4.7	5.4	6.9	8.8	15.3	24.0	32.4
17 years	130	430	12.7	9.28	0.99	4.7	5.4	6.8	9.5	16.3	28.5	34.3
Female												
12 years	127	426	13.6	8.68	0.66	4.6	5.6	7.4	12.0	18.3	25.4	37.0
13 years	142	435	14.2	8.65	0.71	5.3	6.2	7.8	12.3	19.1	27.0	32.4
14 years	161	482	14.9	8.66	0.63	5.3	6.4	8.6	13.3	19.3	27.0	35.0
15 years	139	476	16.7	9.16	0.94	6.6	7.6	10.3	14.0	22.8	30.3	35.4
16 years	126	386	15.2	9.04	1.30	6.1	7.0	8.8	12.5	19.1	27.4	35.5
17 years	118	412	15.3	8.69	1.04	6.8	7.8	10.6	13.3	18.6	24.3	31.4
WEST												
Male												
12 years	151	538	11.5	8.75	0.77	4.1	4.5	5.6	8.3	15.0	26.5	31.9
13 years	152	490	12.7	9.47	0.79	4.0	4.6	6.0	9.1	18.1	27.7	34.4
14 years	150	489	12.8	9.78	0.73	3.8	4.6	6.4	9.3	15.8	28.7	36.1
15 years	151	475	13.1	8.20	0.89	4.8	5.5	7.3	10.6	15.9	25.9	30.4
16 years	131	453	12.2	7.35	0.81	5.1	5.6	6.8	10.3	15.4	24.4	28.8
17 years	124	492	14.0	9.97	1.71	5.3	5.8	7.4	10.8	16.8	30.5	38.6
Female												
12 years	134	485	12.0	7.15	0.86	4.5	5.2	6.8	10.7	14.6	22.3	27.0
13 years	138	493	14.3	7.53	0.69	5.8	6.8	9.1	12.7	18.6	24.5	30.2
14 years	138	478	15.3	7.63	0.72	6.1	6.9	10.3	13.3	21.1	26.1	28.9
15 years	135	493	16.6	8.32	0.90	5.7	7.1	10.6	15.4	21.8	28.0	31.2
16 years	145	513	16.2	7.77	0.86	7.5	8.7	11.3	14.5	20.2	28.3	31.7
17 years	113	410	16.7	9.34	1.76	5.8	7.5	9.7	13.6	22.7	30.6	33.2

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

Table 20. Medial calf skinfold of youths by geographic region, sex, and age at last birthday: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Geographic region, sex, and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In millimeters									
NORTHEAST												
Male												
12 years	172	471	12.9	6.50	0.69	5.6	6.4	8.3	11.7	16.6	22.4	26.6
13 years	159	466	13.0	7.79	0.53	5.0	6.1	8.2	11.2	15.4	26.4	30.7
14 years	155	463	12.4	8.55	0.74	4.9	5.5	6.8	10.7	15.2	22.1	26.8
15 years	137	393	11.3	7.08	0.63	4.6	5.3	7.2	9.7	13.4	21.2	27.3
16 years	123	370	10.8	6.05	0.68	4.4	4.9	6.5	8.9	13.8	21.1	23.6
17 years	118	364	11.5	7.30	0.49	4.5	5.1	6.4	9.5	15.5	21.7	28.8
Female												
12 years	131	457	15.9	6.78	0.73	8.0	8.6	11.2	14.4	19.7	27.4	30.5
13 years	145	430	17.2	7.05	0.40	7.5	9.9	11.8	16.2	22.6	26.3	30.2
14 years	139	411	18.4	6.77	0.98	9.4	10.7	13.8	18.3	22.2	26.8	30.7
15 years	119	392	18.3	7.14	0.60	8.7	10.6	14.1	17.3	22.0	29.2	35.4
16 years	124	386	20.1	7.06	0.46	9.3	11.4	15.9	19.4	25.5	29.8	31.5
17 years	104	375	19.7	7.69	0.36	9.7	11.3	15.0	19.0	24.3	29.0	31.3
MIDWEST												
Male												
12 years	166	565	12.5	7.49	0.50	4.7	5.6	7.6	11.1	15.7	23.6	27.9
13 years	162	579	12.2	6.79	0.78	5.2	6.0	7.3	10.8	15.8	21.7	25.8
14 years	162	538	11.9	6.58	0.69	5.1	5.5	7.2	10.5	15.3	21.5	25.6
15 years	162	571	11.0	6.73	0.75	5.1	5.6	6.7	9.3	13.5	20.3	25.6
16 years	151	526	10.2	5.89	0.54	4.6	5.2	6.4	8.5	12.6	19.4	22.2
17 years	116	474	9.0	6.07	0.67	3.9	4.4	5.5	7.6	10.7	15.0	20.8
Female												
12 years	147	576	16.2	6.72	0.51	7.8	9.9	11.6	14.5	20.6	25.5	30.7
13 years	156	584	17.0	7.60	0.65	7.8	8.8	11.9	15.9	21.5	28.2	31.7
14 years	144	515	18.7	7.47	0.58	9.2	11.0	12.6	17.6	24.1	29.5	33.4
15 years	107	478	19.1	7.21	1.05	8.6	10.7	14.9	18.7	23.6	30.2	33.8
16 years	139	497	19.7	7.63	0.76	10.5	11.5	14.4	19.6	22.9	28.6	34.7
17 years	131	532	20.4	7.76	1.04	9.3	10.7	15.3	19.7	24.5	32.4	34.8
SOUTH												
Male												
12 years	147	441	11.2	6.39	0.41	4.5	5.2	6.8	10.2	14.8	18.8	21.6
13 years	147	444	11.7	6.63	0.62	4.2	5.4	7.2	10.3	15.7	21.6	24.5
14 years	148	451	9.7	5.36	0.39	4.6	5.3	6.6	8.2	11.5	16.8	21.4
15 years	161	454	10.3	6.35	0.58	4.5	5.0	6.3	8.6	12.4	19.3	24.0
16 years	149	481	9.8	5.79	0.61	3.8	4.8	6.2	8.1	11.6	18.7	22.6
17 years	129	427	10.2	5.88	0.68	4.2	4.7	6.4	8.6	12.1	19.3	21.7
Female												
12 years	124	415	15.0	7.44	0.62	6.5	7.6	10.5	13.8	17.9	24.3	33.1
13 years	142	435	16.4	7.35	0.69	7.5	8.6	11.2	15.1	20.5	27.5	31.8
14 years	158	471	17.2	6.88	0.63	7.7	9.5	12.4	16.3	22.0	28.0	30.5
15 years	138	474	19.5	8.99	1.24	9.0	10.4	13.5	17.7	25.0	31.6	41.1
16 years	124	379	18.1	7.59	0.91	8.3	10.4	12.6	17.1	23.5	28.4	32.3
17 years	114	401	19.0	7.29	1.07	9.6	11.1	13.4	18.3	23.3	28.2	34.3
WEST												
Male												
12 years	154	543	11.4	6.74	0.58	4.7	5.3	7.0	9.6	14.6	21.3	26.6
13 years	152	490	12.2	7.00	0.62	5.1	5.6	8.0	10.2	15.6	21.8	27.8
14 years	147	481	11.0	6.77	0.87	4.4	5.1	6.4	9.5	14.1	20.3	24.7
15 years	149	469	10.1	5.31	0.57	4.3	4.9	6.5	8.9	12.6	17.7	23.2
16 years	130	451	9.3	5.42	0.50	3.8	4.2	5.6	8.2	11.7	17.8	18.9
17 years	124	493	9.4	5.37	0.73	3.6	4.2	6.0	8.4	12.6	16.5	21.2
Female												
12 years	134	485	14.0	5.91	0.65	7.2	8.2	10.2	13.2	17.3	22.1	24.4
13 years	136	487	15.9	6.47	1.02	7.3	7.9	11.6	14.8	20.1	23.8	27.7
14 years	138	478	16.9	6.66	1.15	8.7	9.5	12.4	15.6	21.2	26.8	28.6
15 years	133	486	17.8	7.31	0.91	9.1	10.1	12.7	17.0	22.3	25.9	30.3
16 years	143	506	18.3	6.66	0.84	9.3	11.1	13.8	17.7	22.5	28.2	30.1
17 years	111	402	19.3	7.96	1.24	9.1	11.0	13.5	17.8	23.7	31.3	35.1

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

Table 21. Triceps skinfold of youths 12-17 years of age weighing less than 30 kilograms, by sex and age at last birthday: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Sex and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
Male			In millimeters									
12 years	24	69	6.6	2.41	0.61	2.9	4.6	5.3	6.1	7.7	10.7	11.6
13 years	5	15	*	*	*	*	*	*	*	*	*	*
14 years	1	5	*	*	*	*	*	*	*	*	*	*
15 years	-	-	-	-	-	-	-	-	-	-	-	-
16 years	-	-	-	-	-	-	-	-	-	-	-	-
17 years	-	-	-	-	-	-	-	-	-	-	-	-
Female												
12 years	12	44	6.8	1.51	0.64	5.1	5.3	5.6	7.3	8.4	9.0	9.0
13 years	4	12	*	*	*	*	*	*	*	*	*	*
14 years	-	-	-	-	-	-	-	-	-	-	-	-
15 years	-	-	-	-	-	-	-	-	-	-	-	-
16 years	-	-	-	-	-	-	-	-	-	-	-	-
17 years	16	56	6.8	1.69	0.53	5.0	5.2	5.7	7.0	8.4	9.6	10.0

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

Table 22. Triceps skinfold of youths 12-17 years of age weighing 30-34.9 kilograms, by sex and age at last birthday: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Sex and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
Male			In millimeters									
12 years	99	290	7.3	1.94	0.24	5.0	5.3	6.0	7.4	8.8	9.9	10.8
13 years	30	88	7.1	2.82	0.72	3.7	4.2	5.2	7.1	8.6	11.2	12.8
14 years	3	8	*	*	*	*	*	*	*	*	*	*
15 years	-	-	-	-	-	-	-	-	-	-	-	-
16 years	-	-	-	-	-	-	-	-	-	-	-	-
17 years	-	-	-	-	-	-	-	-	-	-	-	-
Female												
12 years	43	156	8.5	3.99	0.39	4.5	5.0	6.6	8.1	11.3	13.4	14.1
13 years	11	32	8.8	3.71	1.22	3.5	5.2	7.2	8.6	10.7	17.0	17.3
14 years	4	12	*	*	*	*	*	*	*	*	*	*
15 years	1	5	*	*	*	*	*	*	*	*	*	*
16 years	-	-	-	-	-	-	-	-	-	-	-	-
17 years	-	-	-	-	-	-	-	-	-	-	-	-

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

Table 23. Triceps skinfold of youths 12-17 years of age weighing 35-39.9 kilograms, by sex and age at last birthday: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Sex and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
Male			In millimeters									
12 years	158	536	8.2	2.95	0.26	4.3	5.1	6.3	7.7	10.4	12.4	14.0
13 years	91	309	7.7	2.86	0.34	4.1	4.5	5.8	7.6	9.7	12.1	13.4
14 years	32	106	6.3	2.38	0.35	3.4	3.9	5.1	5.9	7.7	9.5	9.9
15 years	4	10	*	*	*	*	*	*	*	*	*	*
16 years	2	5	*	*	*	*	*	*	*	*	*	*
17 years	-	-	-	-	-	-	-	-	-	-	-	-
Female												
12 years	87	329	9.2	2.88	0.29	5.4	6.1	7.4	8.8	11.3	12.6	14.4
13 years	72	253	8.7	2.81	0.38	5.3	5.8	6.9	8.6	10.7	11.8	12.8
14 years	26	76	8.3	2.60	0.47	4.3	5.3	6.7	8.4	10.3	11.1	12.5
15 years	11	34	8.5	3.55	0.83	4.4	4.9	5.7	8.6	10.6	12.8	16.2
16 years	2	4	*	*	*	*	*	*	*	*	*	*
17 years	5	15	9.1	2.40	1.09	7.2	7.4	8.0	8.6	9.6	14.0	14.0

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

Table 24. Triceps skinfold of youths 12-17 years of age weighing 40-44.9 kilograms, by sex and age at last birthday: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Sex and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
Male			In millimeters									
12 years	133	436	10.0	3.64	0.35	5.3	6.0	7.1	10.2	13.1	14.8	16.4
13 years	112	337	8.5	3.32	0.26	4.5	5.1	6.4	7.8	10.8	13.7	15.4
14 years	61	196	7.3	2.98	0.42	3.6	4.2	5.1	7.2	10.3	12.1	12.6
15 years	19	58	6.0	1.78	0.38	3.5	4.0	4.7	6.3	7.6	8.6	9.0
16 years	6	24	6.2	1.02	0.54	4.7	4.9	5.4	6.6	7.2	7.4	7.4
17 years	1	3	*	*	*	*	*	*	*	*	*	*
Female												
12 years	118	428	10.7	3.24	0.28	6.3	7.1	8.5	10.6	13.0	15.8	16.6
13 years	101	342	10.2	3.19	0.44	5.7	6.5	8.2	10.2	12.4	15.3	16.3
14 years	58	176	10.3	3.60	0.60	6.0	6.4	7.6	10.2	12.7	14.9	18.0
15 years	47	174	10.4	3.18	0.47	5.9	6.5	8.2	10.7	12.4	14.5	17.1
16 years	34	96	11.6	3.66	0.89	6.6	7.6	9.8	11.4	13.2	17.3	19.3
17 years	27	93	11.1	2.34	0.51	7.4	7.7	10.2	11.1	12.8	14.8	15.6

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

Table 25. Triceps skinfold of youths 12-17 years of age weighing 45-49.9 kilograms, by sex and age at last birthday: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Sex and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In millimeters									
Male												
12 years	89	299	11.5	5.33	0.76	5.5	6.1	7.7	10.3	13.8	20.6	22.4
13 years	119	396	8.9	3.44	0.26	4.8	5.4	6.9	8.6	11.0	13.2	16.6
14 years	86	264	7.4	3.18	0.32	3.7	4.2	5.3	7.1	9.2	12.9	14.4
15 years	62	185	7.0	2.68	0.31	4.2	4.4	5.3	6.6	9.2	11.1	13.0
16 years	25	83	5.6	1.85	0.35	4.0	4.1	4.5	5.4	6.8	8.2	9.5
17 years	12	40	5.6	1.96	0.59	3.2	3.4	4.5	5.6	6.6	8.6	10.0
Female												
12 years	106	372	12.6	4.27	0.60	7.2	7.8	9.7	12.4	15.8	18.2	21.0
13 years	122	399	11.0	3.43	0.30	6.6	7.3	8.6	11.0	13.3	15.7	17.2
14 years	143	470	12.0	3.26	0.40	7.1	8.3	10.0	11.9	14.7	17.0	17.6
15 years	91	333	12.7	4.10	0.48	7.0	8.1	9.4	12.5	15.3	18.7	21.1
16 years	90	293	12.1	4.08	0.56	6.7	7.4	9.4	12.2	14.5	18.0	20.9
17 years	76	280	12.2	4.18	0.83	6.6	7.4	9.3	11.8	15.4	18.5	20.1

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

Table 26. Triceps skinfold of youths 12-17 years of age weighing 50-54.9 kilograms, by sex and age at last birthday: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Sex and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In millimeters									
Male												
12 years	56	161	15.0	6.06	0.92	6.4	7.4	10.3	14.8	20.2	24.3	26.0
13 years	88	275	10.2	4.89	0.36	4.8	5.4	6.6	9.2	13.5	18.1	20.5
14 years	123	373	8.1	4.25	0.30	4.2	4.5	5.5	7.4	9.6	14.0	15.5
15 years	93	278	6.8	2.36	0.25	4.3	4.6	5.5	6.6	8.3	10.4	11.2
16 years	56	184	6.6	2.61	0.42	3.9	4.2	5.0	6.3	8.1	10.7	13.2
17 years	32	116	5.9	2.03	0.50	3.1	4.0	4.7	5.8	7.4	8.4	10.2
Female												
12 years	76	273	14.3	3.99	0.61	9.3	10.2	11.5	14.2	17.0	20.8	22.5
13 years	97	337	14.3	4.47	0.41	7.8	9.4	11.1	13.9	17.0	21.1	24.2
14 years	124	385	13.7	4.92	0.36	7.4	8.4	10.2	12.9	16.8	20.4	22.7
15 years	106	388	13.7	3.62	0.44	8.4	9.5	11.4	13.7	15.9	18.9	20.6
16 years	136	442	13.3	4.32	0.33	7.9	8.6	10.6	12.8	16.2	19.5	21.3
17 years	103	387	15.3	4.85	0.54	7.8	9.7	12.2	15.2	18.5	21.8	24.2

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

Table 27. Triceps skinfold of youths 12-17 years of age weighing 55-59.9 kilograms, by sex and age at last birthday: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Sex and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In millimeters									
Male												
12 years-------	48	139	16.4	6.17	0.99	6.2	7.6	12.8	16.4	22.2	24.5	26.4
13 years-------	69	223	12.2	6.16	0.76	5.2	5.6	7.5	11.1	17.5	20.5	22.5
14 years-------	106	346	8.4	4.37	0.48	4.6	5.2	6.1	7.3	10.1	15.1	18.4
15 years-------	120	396	7.0	3.22	0.34	4.0	4.3	5.3	6.6	8.2	10.7	12.6
16 years-------	108	367	6.6	2.39	0.19	3.8	4.5	5.4	6.4	7.8	10.2	11.3
17 years-------	67	243	6.0	1.76	0.26	4.1	4.4	5.1	5.7	7.2	8.6	10.0
Female												
12 years-------	51	182	17.8	5.91	0.90	9.1	10.2	13.6	18.0	23.0	25.6	28.3
13 years-------	81	275	16.2	4.66	0.54	8.8	10.6	13.5	16.3	19.5	22.7	25.6
14 years-------	98	347	15.7	4.18	0.41	10.3	10.8	12.3	15.2	19.2	21.7	22.7
15 years-------	113	406	15.8	4.54	0.42	9.6	10.6	13.1	15.8	18.4	22.4	24.3
16 years-------	105	342	16.3	4.92	0.52	8.2	10.2	13.2	16.5	20.3	23.3	25.2
17 years-------	105	409	16.4	4.60	0.43	9.8	10.6	12.7	16.6	19.8	22.7	25.3

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

Table 28. Triceps skinfold of youths 12-17 years of age weighing 60-64.9 kilograms, by sex and age at last birthday: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Sex and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In millimeters									
Male												
12 years-------	18	49	20.3	7.90	2.30	7.6	9.5	12.7	22.3	27.4	29.7	33.7
13 years-------	52	169	13.6	6.90	1.34	5.2	5.5	7.5	13.3	20.2	24.5	26.6
14 years-------	72	231	10.0	4.92	0.52	4.6	5.5	7.1	8.2	12.7	18.2	20.4
15 years-------	114	350	7.9	3.24	0.30	4.6	5.1	5.6	7.3	10.1	12.7	15.5
16 years-------	117	378	7.1	2.96	0.24	3.6	4.2	5.3	6.6	8.7	12.1	12.9
17 years-------	108	397	6.7	2.61	0.29	3.7	4.2	5.1	6.2	8.4	10.3	12.3
Female												
12 years-------	29	100	21.7	5.29	0.87	12.6	15.2	18.5	22.3	25.6	26.8	29.4
13 years-------	41	133	20.1	4.86	0.71	11.8	12.9	17.1	20.7	24.2	25.5	28.1
14 years-------	61	207	18.7	4.55	0.45	12.6	13.7	15.7	18.3	22.4	25.2	27.0
15 years-------	52	192	17.8	4.86	0.86	12.1	12.6	14.2	17.2	20.8	25.1	25.9
16 years-------	74	263	18.6	4.68	0.69	12.3	12.8	14.8	19.6	21.9	24.7	26.5
17 years-------	74	263	17.9	5.02	0.75	10.9	11.5	14.1	18.3	22.1	24.3	25.9

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

Table 29. Triceps skinfold of youths 12-17 years of age weighing 65-69.9 kilograms, by sex and age at last birthday: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Sex and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In millimeters									
Male												
12 years	10	30	24.0	4.38	1.84	16.6	20.1	20.5	27.0	28.2	30.0	30.0
13 years	23	80	14.5	6.66	1.52	6.2	7.0	10.7	12.1	19.5	26.2	27.5
14 years	59	188	12.0	5.16	0.70	5.8	6.4	8.2	11.4	15.5	19.2	20.8
15 years	83	269	9.6	4.54	0.52	4.3	5.1	7.1	8.7	12.3	15.4	21.2
16 years	96	327	9.1	3.69	0.44	5.2	5.5	6.9	7.8	11.7	14.9	16.5
17 years	91	319	7.8	3.44	0.51	4.3	4.7	5.7	7.1	9.8	13.1	14.7
Female												
12 years	10	34	24.5	6.63	2.69	14.6	17.2	20.8	24.1	30.3	31.9	39.0
13 years	27	83	22.2	4.11	0.79	16.3	17.1	20.4	22.3	25.1	28.1	28.8
14 years	31	100	21.4	4.91	1.28	12.3	13.4	18.0	22.4	25.4	28.1	28.3
15 years	27	102	19.9	6.18	1.12	10.5	13.0	16.3	20.3	23.6	29.3	30.6
16 years	36	145	19.5	4.08	0.66	13.2	13.8	16.7	20.6	22.6	25.3	26.2
17 years	35	132	17.8	4.71	1.00	12.2	12.6	14.1	17.9	21.2	24.6	27.6

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

Table 30. Triceps skinfold of youths 12-17 years of age weighing 70-74.9 kilograms, by sex and age at last birthday: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Sex and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In millimeters									
Male												
12 years-------	4	10	*	*	*	*	*	*	*	*	*	*
13 years-------	12	46	18.4	4.97	1.46	11.3	11.6	15.3	17.3	22.3	22.9	26.8
14 years-------	26	81	13.2	5.03	1.06	6.4	7.2	9.2	13.4	17.6	21.1	22.4
15 years-------	53	164	11.3	4.84	0.90	6.1	6.5	8.1	10.2	15.2	17.8	20.8
16 years-------	55	181	11.0	4.76	0.75	5.4	6.3	7.6	10.1	13.8	18.0	19.8
17 years-------	68	245	9.5	4.27	0.44	4.3	5.0	6.0	9.6	12.0	14.7	16.5
Female												
12 years-------	8	28	24.1	4.22	1.67	17.4	17.7	22.0	25.3	28.1	30.0	30.0
13 years-------	8	24	24.9	3.69	1.97	18.7	21.0	21.7	26.9	28.2	30.0	30.0
14 years-------	25	73	24.2	5.31	1.24	17.4	18.8	21.2	23.5	27.8	31.6	32.6
15 years-------	21	92	21.7	6.16	1.83	7.4	7.9	19.7	22.8	25.5	27.9	29.6
16 years-------	18	68	23.8	5.44	1.38	15.5	17.2	20.1	24.4	28.4	31.3	34.1
17 years-------	16	67	24.8	5.33	1.07	17.2	20.0	21.5	23.6	27.7	33.1	39.0

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

Table 31. Triceps skinfold of youths 12-17 years of age weighing 75-79.9 kilograms, by sex and age at last birthday: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Sex and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In millimeters									
Male												
12 years-------	3	11	*	*	*	*	*	*	*	*	*	*
13 years-------	12	30	19.2	5.21	1.91	12.8	13.1	13.6	19.6	23.0	25.7	29.0
14 years-------	27	85	14.3	6.59	1.97	7.4	8.2	10.5	13.8	16.0	21.8	32.1
15 years-------	21	58	15.8	7.71	1.51	8.1	9.0	10.3	13.5	20.5	28.5	29.5
16 years-------	39	127	13.0	6.26	1.32	5.4	5.9	8.1	11.0	18.6	23.1	23.8
17 years-------	51	182	12.0	4.71	0.56	5.6	7.0	8.7	11.8	14.7	16.5	22.2
Female												
12 years-------	4	11	*	*	*	*	*	*	*	*	*	*
13 years-------	6	21	22.8	4.08	2.80	13.4	13.9	20.6	25.1	25.7	27.0	27.0
14 years-------	6	20	25.7	5.03	2.56	16.3	16.6	23.7	25.7	27.7	33.0	33.0
15 years-------	11	36	29.1	4.38	1.58	21.8	22.4	27.4	29.6	31.8	32.9	38.0
16 years-------	12	35	26.1	4.57	2.08	19.5	20.0	22.0	28.0	29.5	31.4	35.0
17 years-------	8	37	27.0	7.15	4.72	15.4	15.8	22.3	28.3	32.5	36.0	36.0

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

Table 32. Triceps skinfold of youths 12-17 years of age weighing 80-84.9 kilograms, by sex and age at last birthday: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Sex and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
Male			In millimeters									
12 years	-	-	-	-	-	-	-	-	-	-	-	-
13 years	3	8	*	*	*	*	*	*	*	*	*	*
14 years	7	21	17.8	2.87	1.22	14.6	14.7	15.6	18.2	20.5	23.0	23.0
15 years	16	53	17.1	4.27	1.37	11.4	11.8	15.3	17.2	18.5	26.2	28.0
16 years	24	69	15.3	5.56	1.28	6.4	6.9	12.2	14.6	20.6	23.1	25.0
17 years	17	65	13.0	4.53	1.28	7.1	7.8	9.8	12.4	17.4	19.7	20.7
Female												
12 years	1	3	*	*	*	*	*	*	*	*	*	*
13 years	8	25	29.5	7.42	3.19	17.6	20.1	20.9	28.6	36.2	40.0	40.0
14 years	3	9	*	*	*	*	*	*	*	*	*	*
15 years	9	32	27.1	2.08	0.79	24.4	24.8	25.6	27.5	28.6	30.6	32.0
16 years	10	38	31.2	7.30	2.66	16.8	23.6	26.0	31.1	40.0	40.0	40.0
17 years	5	16	23.6	5.98	3.51	17.1	17.2	17.6	23.4	31.0	31.3	31.4

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

Table 33. Triceps skinfold of youths 12-17 years of age weighing 85-89.9 kilograms, by sex and age at last birthday: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Sex and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In millimeters									
Male												
12 years------	-	-	-	-	-	-	-	-	-	-	-	-
13 years------	5	13	*	*	*	*	*	*	*	*	*	*
14 years------	5	13	*	*	*	*	*	*	*	*	*	*
15 years------	13	35	22.6	5.61	1.68	9.5	16.3	21.0	21.9	29.0	29.8	30.0
16 years------	10	32	14.4	4.96	1.68	9.8	10.2	10.8	12.6	19.1	20.7	26.2
17 years------	15	47	14.9	5.74	1.92	7.8	8.3	12.3	14.2	21.1	25.6	26.0
Female												
12 years------	2	8	*	*	*	*	*	*	*	*	*	*
13 years------	-	-	-	-	-	-	-	-	-	-	-	-
14 years------	2	5	*	*	*	*	*	*	*	*	*	*
15 years------	7	32	30.9	4.68	1.34	22.4	22.9	28.1	32.5	33.7	34.9	39.0
16 years------	7	22	25.4	10.55	4.70	9.7	9.8	17.4	25.4	35.4	40.0	40.0
17 years------	5	17	30.7	2.49	1.64	28.3	28.5	29.3	30.3	30.9	35.0	35.0

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

Table 34. Triceps skinfold of youths 12-17 years of age weighing 90-99.9 kilograms, by sex and age at last birthday: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Sex and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile 5th	10th	25th	50th	75th	90th	95th
			In millimeters									
Male												
12 years-------	1	2	*	*	*	*	*	*	*	*	*	*
13 years-------	2	7	*	*	*	*	*	*	*	*	*	*
14 years-------	7	26	27.4	7.25	4.64	15.5	16.0	22.5	32.2	32.6	37.0	37.0
15 years-------	8	26	16.7	4.05	1.74	10.7	10.8	14.2	17.1	21.2	21.4	21.4
16 years-------	11	37	17.7	4.08	1.94	11.7	11.9	13.8	17.5	20.7	24.1	24.3
17 years-------	19	78	20.7	6.93	2.93	9.5	11.7	15.7	20.4	26.9	32.0	32.0
Female												
12 years-------	-	-	-	-	-	-	-	-	-	-	-	-
13 years-------	4	10	*	*	*	*	*	*	*	*	*	*
14 years-------	3	10	*	*	*	*	*	*	*	*	*	*
15 years-------	2	6	*	*	*	*	*	*	*	*	*	*
16 years-------	9	29	31.8	4.60	1.48	26.2	26.5	27.4	32.3	35.4	40.4	40.0
17 years-------	6	20	32.9	7.56	4.03	17.6	17.7	31.8	34.2	40.1	40.4	40.4

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

Table 35. Triceps skinfold of youths 12-17 years of age weighing 100 kilograms or more, by sex and age at last birthday: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Sex and age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In millimeters									
Male												
12 years-------	-	-	-	-	-	-	-	-	-	-	-	-
13 years-------	3	9	*	*	*	*	*	*	*	*	*	*
14 years-------	3	5	*	*	*	*	*	*	*	*	*	*
15 years-------	7	18	21.4	6.87	2.65	12.6	12.8	14.6	20.5	26.1	34.0	34.0
16 years-------	7	19	*	*	*	*	*	*	*	*	*	*
17 years-------	8	29	*	*	*	*	*	*	*	*	*	*
Female												
12 years-------	-	-	-	-	-	-	-	-	-	-	-	-
13 years-------	-	-	-	-	-	-	-	-	-	-	-	-
14 years-------	2	9	*	*	*	*	*	*	*	*	*	*
15 years-------	5	16	*	*	*	*	*	*	*	*	*	*
16 years-------	3	10	*	*	*	*	*	*	*	*	*	*
17 years-------	4	9	*	*	*	*	*	*	*	*	*	*

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

Table 36. Area of arm at triceps, estimated area of muscle and bone, and estimated area of fat for males and females 6-17 years of age: United States, 1963-70

Sex and age	Area of arm[1]	Estimated area of muscle and bone[1]	Estimated area of fat[2]
	In square millimeters		
Male			
6 years	2,410	1,761	649
7 years	2,586	1,926	660
8 years	2,764	2,052	712
9 years	2,964	2,183	781
10 years	3,135	2,320	815
11 years	3,454	2,552	902
12 years	4,051	3,011	1,040
13 years	4,547	3,452	1,095
14 years	5,127	4,089	1,038
15 years	5,645	4,623	1,022
16 years	6,000	4,968	1,032
17 years	6,348	5,233	1,115
Female			
6 years	2,380	1,662	718
7 years	2,565	1,754	811
8 years	2,828	1,901	927
9 years	3,043	2,068	975
10 years	3,332	2,214	1,118
11 years	3,573	2,436	1,137
12 years	4,242	2,976	1,266
13 years	4,471	3,092	1,379
14 years	4,775	3,207	1,568
15 years	5,142	3,367	1,775
16 years	5,119	3,350	1,769
17 years	5,231	3,331	1,900

[1]Median.
[2]Estimated area of fat = area of arm - estimated area of muscle and bone.

Table 37. Comparison of skewness ratios between races and sexes[1] for skinfolds of children and youths: United States, 1963-70

Comparative race or sex group	Skinfold				
	Triceps	Medial calf	Sub-scapular	Midax-illary	Supra-iliac
White ratio greater than Negro ratio	7	2	15	16	4
Negro ratio greater than white ratio	16	10	8	7	8
White ratio equal to Negro ratio	1	0	1	1	0
Male ratio greater than female ratio	18	11	13	15	11
Female ratio greater than male ratio	6	1	11	10	1
Male ratio equal to female ratio	0	0	0	0	0

[1]Number of times one ratio was greater than another, comparisons made by age and either race or sex.

APPENDIX I
STATISTICAL NOTES

The Survey Design

The sampling plan of the third cycle of the Health Examination Survey followed a multistage, stratified probability sample of clusters of households in land-based segments in which a sample of the United States population (including Alaska and Hawaii) aged 12 through 17 years was selected. Excluded were those youths confined to institutions and those residing upon any of the reservation lands set aside for use by American Indians.

The sample design of Cycle III is similar to that of Cycle II in that it utilizes the same 40 sample areas and the same segments. The decision to incorporate this feature into Cycle III was not made prior to the selection of the second cycle sample although it is consistent with the early concept of a single program for 6-17 year olds. The final decision to utilize this identical sampling frame was made during the operation of the second cycle program.

The successive elements for this sample design are primary sampling unit; census enumeration district; segment (a cluster of households); household; all eligible youths; and finally, sample youth. Every eligible youth within the defined population has a known and approximately equal chance for selection into the sample.

The steps of drawing the sample were carried out jointly with the Bureau of the Census; the starting points were the 1960 decennial census lists of addresses and the nearly 1,900 primary sampling units (PSU's) into which the entire United States was divided. Each PSU is a standard metropolitan statistical area (SMSA), a county, or a group of two or three contiguous counties. These PSU's were grouped into 40 strata so that each stratum had an average size of about 4.5 million persons. This grouping was done in a manner which maximized the degree of homogeneity within strata with regard to the population size of the PSU's, degree of urbanization, geographic proximity, and degree of industrialization. The 40 strata were then classified into four broad geographic regions of 10 strata each and then within each region, cross-classified by four population density classes and by the rates of population change from 1950 to 1960. Using a modified Goodman-Kish controlled-selection technique, one PSU was drawn from each of the 40 strata.

The sampling within PSU's was carried out in several steps. The first was the selection of census enumeration districts (ED's). These ED's are small well-defined areas of about 250 housing units into which the entire Nation was divided for the 1960 population census. Each ED was assigned a "measure of size" equal to the rounded whole number resulting from a "division by nine" of the number of children aged 5-9 in the ED at the time of the 1960 census. A sample of 20 ED's in the sample PSU was selected according to a systematic sampling technique with each ED having a probability of selection proportional to the population of children 5-9 years at the time of the 1960 census date. From each ED a random selection of one measure of size (segment) was taken.

Minor changes required in the Cycle III design were that it be supplemented for new construction to a greater extent than had been necessary in Cycle II and that reserve segments be added. Although it was the plan for Cycle III to use the Cycle II segments, it was recognized that within several PSU's, additional reserve segments would be needed to avoid the risk of having an insufficient number of examinees. This was prompted by the fact that four of the PSU's in Cycle II had yields of less than 165 eligible children and several others were marginal in their yield. In addition, there was a 3-year interval between Cycle II and Cycle III, so that it was quite possible for some segments to have been completely demolished to make room for highway construction or urban redevelopment.

The time available for examinations at a particular location or stand, as they have been designated, is necessarily set far in advance of any preliminary field work at the stand. Therefore, the number of examinations that can be performed at a particular location is dependent upon the number of examining days available. At the majority of locations the number of days available, excluding Saturdays, is 17. At the rate of 12 examinations each day, this provides for 204 examination slots. Examinations are conducted on Saturdays if for some reason it is necessary. Because of rescheduling for cancellations or no-shows, the maximum number of youths that is considered for inclusion in the sample is 200. When the number of eligible youths exceeds this number, subsampling is performed to reduce the number to manageable limits. This is accomplished through the use of a master list which is a listing of all eligible youths in order by segment, serial number (household order within segment), and column number (order in the household by age). After the subsampling rate has been determined, every n^{th} name on the list is deleted, starting with the y^{th} name, y being a randomly selected number between 1 and n. Youths who are deleted from the Cycle III sample but who were examined in Cycle II as well as any twin who may have been deleted are, if time permits, scheduled for an examination for inclusion only in the longitudinal study portion or twin study portion of the survey. Their data are not included in the report as part of the regular sample.

Since the strata are roughly equal in population size and a nearly equal number of sample youths 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 12 through 17 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 youths in a sample PSU having the same age (in years) and sex as those not examined in that sample PSU.

The poststratified ratio adjustment used in the third 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 March 9, 1968 (approximate midsurvey point) by color and sex for each single year of age 12 through 17. The weight of every responding sample child in each of the 24 age, race, and sex classes is 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 *Vital and Health Statistics*, Series 2, Number 43,[19] "Sample Design and Estimation Procedures for a National Health Examination Survey of Children," and in Series 1, Numbers 1,[20] 5,[3] and 8,[4] which describe the plan and operation of the first three cycles of the Health Examination Survey (HES).

Some Notes on Response Rates

As mentioned previously, the sample designs of the second and third cycles of the HES were similar.

NOTE: The list of references follows the text.

Differences did occur, however, in response rates of various subgroups of these samples and these differences deserve some consideration here.

Most importantly, the number of youths selected for examination increased from 7,417 in Cycle II to 7,514 in Cycle III. The response rate, that is, the number of youths selected who were actually examined, decreased from 96 percent in Cycle II to 90 percent in Cycle III. Of the examined youths of Cycle II, 13.86 percent were Negro compared with 14.76 percent of those examined in Cycle III. This difference does not reflect a difference in the percentage of Negro youths selected for examination, but instead, a smaller decrease in response rate for Negro youths between the two cycles than was the case for the white youths. In actuality, 13.8 percent of the sample selected for examination was Negro in Cycle III corresponding to 13.5 percent for Cycle II. However, whereas the response rate for white youths dropped from 95.6 percent in Cycle II to 89.1 percent in Cycle III, the response rate for Negro youths dropped a far lesser degree from 98.4 percent to 96.6 percent. Thus, better relative response from the Negro portion of the sample yielded a greater percentage of these youths actually examined during Cycle III than was the case during the previous sample.

Examination of sample sizes in this report clearly shows that at every age group there were fewer girls actually examined than there were boys of the same age. This again is not attributed to differences in numbers of youths selected in the sampling design, but rather to the following differential response rates between males and females:

Age	*Male*	*Female*
12	93.5	91.3
13	93.2	91.9
14	91.7	90.7
15	91.6	87.9
16	89.8	87.7
17	87.6	81.8
Total	91.4	88.7

Note that at each age group the response rate for boys exceeded that of girls.

A similar analysis of response rates can be done by age, race, and sex as follows:

Age	*White male*	*Negro male*	*White female*	*Negro female*
12	92.6	99.0	90.1	98.9
13	92.5	98.8	91.1	96.8
14	91.0	97.8	89.6	96.2
15	90.7	97.7	86.4	98.6
16	89.2	95.0	86.6	93.0
17	86.5	95.8	80.2	91.4
Total	90.5	97.6	87.4	95.8

The above clearly indicates that for all ages under consideration in Cycle III of the HES, the response rate for Negro youths exceeded that of white youths of the same sex and age.

Reasons for differences in response rates are many but may range from the incentive to get examined in order to miss a day of school, to fear of the examination itself, to inhibitions with respect to being examined. The worst response rate was recorded for the oldest girls, i.e., 17-year-old females.

Parameter and Variance Estimation

As each of the 6,768 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: $\overline{X}=\sum_{i=1}^{n} W_i \; X_i / \Sigma W_i$, 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." [2]

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 (6,768 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 which contains the estimated variance 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,

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

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.[21]

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 enough to meet the standards established for publication.

To illustrate these criteria, in table 21 all values of the distribution of skinfolds for 14-year-old males weighing less than 30 kilograms were replaced by asterisks (*) since there were less than five people of that age, sex, and weight. Furthermore, in that same table, although there were five 13-year-old boys, the distributions of skinfold values are also replaced by asterisks because the standard error with respect to the mean exceeded the criteria previously stated.

Hypothesis Testing

Although this report is primarily descriptive, it is often desirable to make statistical comparisons between two groups such as males and females or 12-year-olds and 13-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

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

is then compared to a table of normal deviates to determine whether or not there is, in fact, a difference

NOTE: The list of references follows the text.

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 10 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 12 and 17 years" has far more meaning and interpretability than to say "the mean triceps skinfold for 12-year-old girls is significantly greater than the corresponding mean for 12-year-old boys, and the mean.... for 13-year-old girls is significantly greater than the mean for 13-year-old boys, 14-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 6,768 children in the sample five skinfolds were recorded. The correlation coefficients were computed for each of the 10 possible pairs of these five 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 14. As described in the text, it was decided to rank, within each age-sex-race group, the five correlation coefficients under consideration. The distribution of these ranks is shown in table 15.

Imputation

The necessity of arriving at a workable imputation scheme for Cycle III of the HES was dictated by the fact that each individual carries a separate and unique statistical weight, i.e., the number of individuals in the United States population he is said to represent. The decision to drop from the sample such an individual due to missing or erroneous values on some number of variables would not be satisfactory unless the statistical weight was somehow redistributed. The extent of bias introduced in this manner would depend upon the scheme chosen for the redistribution of the individual's statistical weight and would carry along with it the major disadvantage of having unweighted sample sizes differ from variable to variable (thus making correlation procedures more complicated), while, of course, the weighted sample sizes would remain constant.

A regression method of imputation which was selected for the analysis of HES body measurements was desirable and possible for several reasons. First, the number of problem cases was small enough so as not to be unwieldy. Second, the various body measurements collected on an individual are highly correlated and, as such, one would like the imputed value to be harmonious with the other valid measures for that individual. To simply impute a group mean or a randomly selected value to an atypical individual in place of either a nonexistent or an existing but obviously incorrect measurement while ignoring the other valid information on that same individual would be undesirable.

Third, the bias introduced by a regression scheme would clearly be less than would arise if individuals with missing or questionable bits of information were excluded from the sample and their statistical weights redistributed. Fourth, this system has the advantage of holding both the weighted and unweighted sample sizes constant from variable to variable thus facilitating any correlations or cross-tabulations desired. Thus, an elaborate regression scheme was utilized to impute body measurements of the third cycle of the HES.

The procedure was as follows: From the total 6,768 subjects on whom some body measurements were performed, 26 subjects for whom there was one or more missing value were temporarily dropped and four files were created from the remaining 6,742 subjects. The files were white males, Negro males, white females, and Negro females. It was from these subjects that the prediction equations were finally developed.

In a typical case, a subject (for example, a 12-year-old Negro male) might have a body weight recorded which is so low as to raise the question of whether there was an error somewhere in the data preparation process. However, despite this extremely low value, his record would be otherwise complete. Since all the other variables are recorded for this individual, an estimate for body weight is derived based on all the other information available and it is possible to conclude that the recorded measurement is possible considering the youth's other dimensions or that the recorded value is an obvious clerical error and should be changed. Thus, the file with the Negro males who all have complete records is tapped and a stepwise regression is calculated, with body weight the dependent variable. All the remaining variables are eligible for inclusion into the equation with the following restrictions:

(1) Age must be the first variable added into the equation, irrespective of the correlation between age and the dependent variable.

(2) So long as adding a new variable contributed at least .005 (½ percent) to the coefficient of multiple determination (R^2), it was included. If the contribution was less than that, the equation was frozen with all the variables which did add at least that much to R^2. (No equation included more than eight independent variables.)

The resulting equation may be of the form

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots \beta_k X_k$$

where Y is the predicted sitting height, α, β_1, β_2, β_3, etc. are the coefficients generated by the regression, and X_1, X_2, X_3, etc. are the independent variables. By inserting the recorded values for this subject of X_1, X_2, X_3 up to X_k (k being the number of variables contributing significantly to R^2, $k \leq 8$) into the equation, a prediction is arrived at for body weight. A value imputed in this manner is superior to other possible methods since all the relevant information is utilized and allows an extremely large or small person to be assigned a similarly large or small imputed value.

In actuality there were only 19 youths in Cycle III of the HES whose values for any of the five skinfolds were either missing or highly questionable on the original data tape.

NOTE: The list of references follows the text.

To determine whether a skinfold measurement was "questionable," extremes of the distributions of each variable were examined case by case. (Although useful, this procedure allows some highly deviant values to go undetected. For example, hidden in the distribution of triceps skinfolds may be an extremely thin individual who had a mispunched skinfold far too large for his thin build and his other four skinfold measurements but nevertheless within normal bounds for the entire distribution of all triceps skinfolds from the entire HES sample.) But the magnitude of the problem of bad or missing skinfold data in the HES is very small and oversights such as this will not have an appreciable collective effect.

A problem much more prevalent in these skinfold data than those described above is that of "tight skin." In some circumstances, the skin is so tightly bound to the underlying tissue that it cannot be picked up into a double fold by the technician. Code 00.0 was used by the technician to indicate that he was unable to read the skinfold measurement rather than implying that the skinfold existed but was so small that it measured zero.

There were a total of 83 subjects on whom tight skin was recorded for at least one of the skinfolds; and, as can be seen, this most often occurred in the medial calf fold. The frequencies of occurrence of tight skin were as follows:

Triceps:	5
Subscapular:	6
Midaxillary:	4
Suprailiac:	10
Medial calf:	67

Of course, several youths had "tight skin" recorded on more than one of the skinfolds.

A complete description of the problems, the alternatives, and the selected procedure for use in imputation of all the other HES body measurements can be found in a separate document.[22] In addition, a complete log was kept of all changes made on the original Cycle III data and these may be made available upon request.

ooo

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 12-17 years by sex. Birth certificates were obtainable for verification of age for 92 percent of the youths. Age stated by the parents was accepted as the true age for the other 8 percent. Age is expressed as years attained at last birthday.

Race

Skinfolds were reported by race for white and Negro youths. Youths of other races were not sampled sufficiently for comparison purposes; these youths represented only 0.32 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-

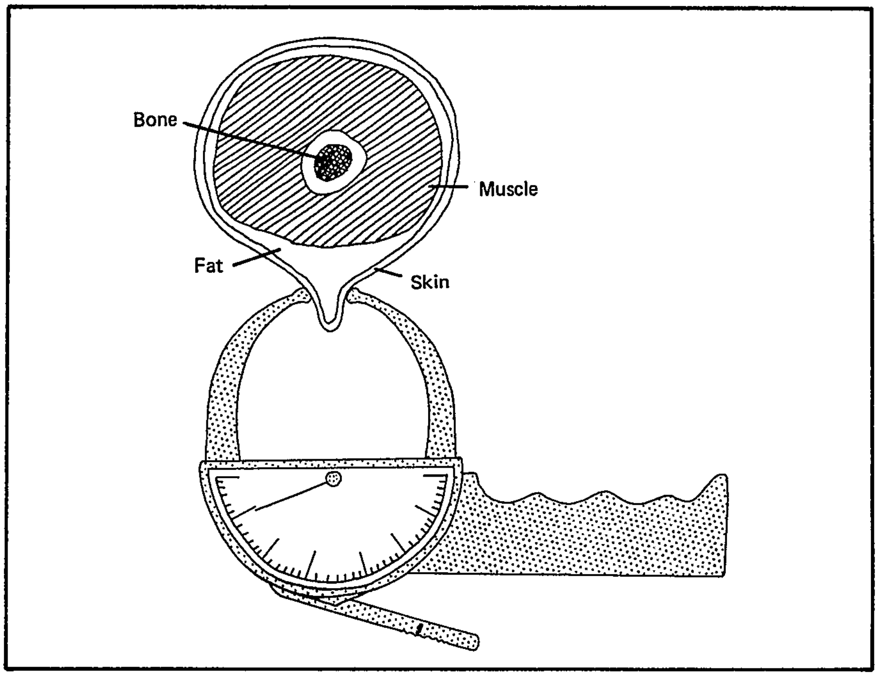

Figure I. Diagram of the technique for measuring a skinfold, a double layer of subcutaneous fat and skin. In this case, the triceps skinfold is being measured with the Lange caliper. (Drawing courtesy of Muriel Kirkpatrick, Dept. of Anthropology, Temple University)

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 [c] 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.*
>
> 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,

[c] 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.

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 sites 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 III five 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; (3) *midaxillary,* in the midaxillary line, but with the fold perpendicular to it, midway between the nipple and the umbilicus; (4) *suprailiac,* just above the iliac crest in the midaxillary line, with the fold perpendicular to it; and (5) *medial calf,* on the medial aspect of the leg near its greatest circumference, the fold running parallel to the long axis of the leg. Diagrams of the five sites are shown in figure III.

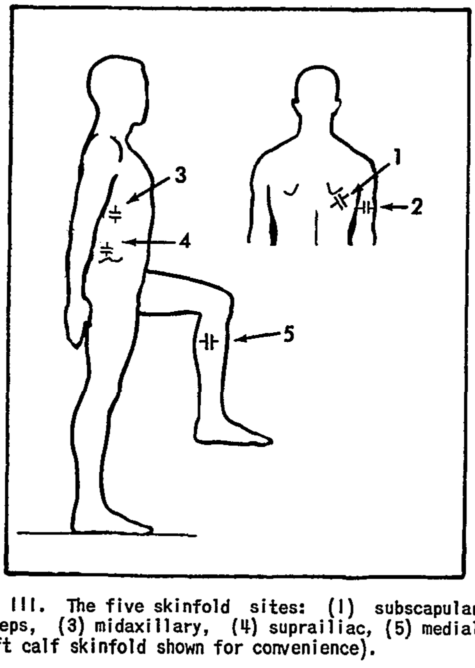

Figure III. The five skinfold sites: (1) subscapular, (2) triceps, (3) midaxillary, (4) suprailiac, (5) medial calf (left calf skinfold shown for convenience).

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 IV).

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 six identifiable procedures, some emphasizing the training component and some the assessment of quality.

(1) Careful training of the examiners.

(2) Periodic direct observation by the medical advisor and the anthropologic consultant as measurements

HEALTH EXAMINATION SURVEY—III

BODY MEASUREMENTS

Measurements in cm. unless otherwise specified.

EXAMINER | RECORDER | BODY MEAS.

CARD COL. NO.	STANDING	CARD COL. NO.	SEATED
8–11	CERVICALE HEIGHT	8–10	BIZYGOMATIC BREADTH
12–15	ACROMIAL HEIGHT	11–13	BIGONIAL BREADTH
16–19	RADIAL HEIGHT	14–16	ELBOW—ELBOW BREADTH
20–23	STYLION HEIGHT	17–19	SEAT BREADTH
24–27	ILIAC CREST HEIGHT	20–22	FOOT LENGTH
28–31	TROCHANTER HEIGHT		**STANDING**
32–35	TIBIAL HEIGHT	23–25	BIACROMIAL BREADTH
	SEATED	26–28	BICRISTAL BREADTH
36–39	SITTING HEIGHT *(Erect)*	29–31	BITROCHANTERIC BREADTH
40–42	THIGH CLEARANCE	32–34	UPPER ARM GIRTH
43–45	SPHYRION HEIGHT	35–37	FOREARM GIRTH
46–48	FOOT BREADTH	38–41	CHEST GIRTH
49	1st TOE RELATIVE TO 2nd TOE: ☐ Longer ☐ Shorter ☐ Same	42–45	WAIST GIRTH
		46–49	HIP GIRTH
50–52	ANKLE BREADTH	50–52	CALF GIRTH
53–55	KNEE BREADTH	53–55	TRICEPS SKINFOLD (mm.)
56–58	ELBOW BREADTH	56–58	SUBSCAPULAR SKINFOLD (mm.)
59–61	WRIST BREADTH	59–61	LATERAL CHEST SKINFOLD (mm.)
62	2nd (Index) FINGER RELATIVE TO 4th (Ring) FINGER: ☐ Longer ☐ Shorter ☐ Same	62–64	SUPRA-ILIAC SKINFOLD (mm.)
		65–68	WEIGHT (lbs.)
63–65	MEDIAL CALF SKINFOLD (mm.)		
66–69	STANDING HEIGHT		

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

PHS-4611-3
REV. 11-66

SAMPLE NO. (1–5)

Figure IV. Body measurement recording form.

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.

(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) 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 Cycle III measurements of skinfolds.

Surveillance and Evaluation of Residual Measurement Process Error

The three following sections are extracted from a recent publication, *Quality Control in a National Health Examination Survey.*[23] 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.

NOTE: The list of references follows the text.

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 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.

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 I 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.

The table below 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

Table I. 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

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[23] 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 five skinfolds of interest and the results are presented below.

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 II.

For four of the five skinfolds the modal difference was 0.5 mm.; for the medial calf the mode was 1.0 mm. The largest mean differences were for the suprailiac (2.43 mm.) and medial calf (2.41 mm.); the triceps, at 1.89 mm., was lower than these, but still higher than the midaxillary (1.33) or subscapular (1.34) skinfolds. The median differences for these latter two were less than for the other three.

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 II. As expected, the largest values belong to the suprailiac and medial calf skinfolds, the triceps displaying an intermediate value and the subscapular and midaxillary sites the smallest.

NOTE: The list of references follows the text.

Triceps:	1.89
Subscapular:	1.53
Midaxillary:	1.47
Suprailiac:	2.45
Medial calf:	2.44

This comparison is somewhat misleading since the suprailiac and medial calf are the largest of the five skinfold measurements and have the greatest variance (see tables 1-5). 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
Suprailiac:	13.93
Medial calf:	14.38

the following are the coefficients of variation:

Triceps:	15.44
Subscapular:	15.37
Midaxillary:	17.39
Suprailiac:	17.67
Medial calf:	17.09

Viewed in terms of relative error the suprailiac and medial calf skinfolds continue to show the poorest replication. However, the midaxillary also falls into this category.

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 III.

Here, the triceps measurement displays the smallest mean difference and, as before, the medial calf and suprailiac the largest. These two also have the largest median differences, the suprailiac being the highest of the five. The technical error of the triceps is the least of the five:

Triceps:	0.80
Subscapular:	1.83
Midaxillary:	2.08
Suprailiac:	1.87
Medial calf:	1.44

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

Absolute difference, d, in mm.	Difference squared, d^2	Triceps skinfold		Subscapular skinfold		Midaxillary skinfold		Suprailiac skinfold		Medial calf skinfold	
		Frequency[1]	Percent	Frequency[1]	Percent	Frequency[1]	Percent	Frequency[1]	Percent	Frequency[1]	Percent
0.0	0.00	21	9.4	48	21.4	40	17.9	25	11.3	23	10.4
0.5	0.25	52	23.2	61	27.2	64	28.6	37	16.7	25	11.3
[2]0.6	0.00	0	0.0	1	0.4	0	0.0	0	0.0	0	0.0
[2]0.9	0.00	0	0.0	1	0.4	0	0.0	0	0.0	0	0.0
1.0	1.00	37	16.5	42	18.7	43	19.2	30	13.5	38	17.1
1.5	2.25	21	9.4	17	7.6	25	11.2	24(26)	10.8	32(34)	14.4
2.0	4.00	16	7.1	15	6.7	17	7.6	19	8.6	23	10.4
2.5	6.25	22	9.8	11	4.9	9	4.0	12	5.4	16	7.2
3.0	9.00	18	8.0	4	1.8	6	2.7	16	7.2	8	3.6
3.5	12.25	10	4.5	3	1.3	3	1.3	15	6.8	12	5.4
4.0	16.00	11	4.9	6	2.7	3	1.3	6	2.7	12	5.4
4.5	20.25	4	1.8	0	0.0	1	0.4	4	1.8	3	1.4
5.0	25.00	1	0.5	5	2.2	6	2.7	6	2.7	8	3.6
5.5	30.25	2	0.9	3	1.3	1	0.4	6	2.7	2	0.9
6.0	36.00	2	0.9	2	0.9	2	0.9	4	1.8	4	1.8
6.5	42.25	2	0.9	1	0.4	0	0.0	4	1.8	4	1.8
7.0	49.00	2	0.9	0	0.0	0	0.0	4	1.8	1	0.5
7.5	56.25	0	0.0	0	0.0	1	0.4	1	0.5	2	0.9
8.0	64.00	0	0.0	1	0.4	1	0.4	2	0.9	2	0.9
8.5	72.25	0	0.0	1	0.4	0	0.0	1	0.5	0	0.0
9.0	81.00	0	0.0	1	0.4	0	0.0	1	0.5	0	0.0
9.5	90.25	0	0.0	0	0.0	1	0.4	0	0.0	1	0.5
10.0	100.00	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
10.5	110.25	0	0.0	1	0.4	1	0.4	1	0.5	2	0.9
11.0	121.00	1	0.5	0	0.0	0	0.0	0	0.0	0	0.0
11.5	132.25	0	0.0	0	0.0	0	0.0	0	0.0	1	0.5
12.0	144.00	1	0.5	0	0.0	0	0.0	1	0.5	0	0.0
12.5	156.25	1	0.5	0	0.0	0	0.0	1	0.5	1	0.5
13.0	169.00	0	0.0	0	0.0	0	0.0	1	0.5	0	0.0
13.5	182.25	0	0.0	0	0.0	0	0.0	1	0.5	1	0.5
16.0	256.00	0	0.0	0	0.0	0	0.0	0	0.0	1	0.5
Sample size, n		224	100.0	224	100.0	224	100.0	222	100.0	222	100.0
Mean difference, $\bar{d}$, in mm.		1.89		1.34		1.33		2.43		2.41	
Median in mm.		1.5		1.0		1.0		1.5		1.5	
Mode in mm.		0.5		0.5		0.5		0.5		1.0	
Σd^2		1601.5		1051.7		971.5		2664.8		2648.5	
$\Sigma d^2/2n$		3.58		2.35		2.17		6.00		5.97	

[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.

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

Absolute difference, d, in mm	Difference squared, d^2	Triceps skinfold		Subscapular skinfold		Midaxillary skinfold		Suprailiac skinfold		Medial calf skinfold	
		Frequency[1]	Percent	Frequency[1]	Percent	Frequency[1]	Percent	Frequency[1]	Percent	Frequency[1]	Percent
0.0	0.00	21	27.3	29	37.7	24	31.2	8	10.4	13	16.9
0.5	0.25	27	35.1	22	28.6	24	31.2	13	16.9	17	22.1
1.0	1.00	13	16.9	11	14.3	14	18.2	13	16.9	14	18.2
1.5	2.25	7	9.1	4	5.2	4	5.2	11	14.3	11	14.3
2.0	4.00	4	5.2	2	2.6	5	6.5	7	9.1	7	9.1
2.5	6.25	2	2.6	2	2.6	1	1.3	4	5.2	3	3.9
3.0	9.00	2	2.6	2	2.6	1	1.3	6	7.8	6	7.8
3.5	12.25	0	0.0	1	1.3	0	0.0	2	2.6	0	0.0
4.0	16.00	1	1.3	1	1.3	0	0.0	5	6.5	3	3.9
4.5	20.25	0	0.0	0	0.0	1	1.3	0	0.0	0	0.0
5.0	25.00	0	0.0	1	1.3	2	2.6	4	5.2	2	2.6
5.5	30.25	0	0.0	0	0.0	0	0.0	1	1.3	0	0.0
6.0	36.00	0	0.0	1	1.3	0	0.0	1	1.3	0	0.0
7.0	49.00	0	0.0	0	0.0	0	0.0	1	1.3	0	0.0
8.5	72.25	0	0.0	0	0.0	0	0.0	1	1.3	0	0.0
10.0	100.00	0	0.0	0	0.0	0	0.0	0	0.0	1	1.3
19.0	261.00	0	0.0	1	1.3	0	0.0	0	0.0	0	0.0
23.0	529.00	0	0.0	0	0.0	1	1.3	0	0.0	0	0.0
Sample size, n		77	100.0	77	100.0	77	100.0	77	100.0	77	100.0
Mean difference, $\bar{d}$, in mm.		0.78		1.05		1.10		1.97		1.44	
Median in mm.		0.5		0.5		0.5		1.5		1.0	
Mode in mm.		0.5		0.0		0.5		1.0		.5	
Σd^2		98.0		514.2		663.5		529.0		330.8	
$\Sigma d^2/2n$		0.64		3.34		4.31		3.44		2.15	

[1]Number of replicate examinations exhibiting indicated differences.

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
Suprailiac:	13.45
Medial calf:	10.36

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

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
Suprailiac:	1.73
Medial calf:	2.72

Tests of these at the .01 level (to keep the overall error rate below 5 percent) showed that the triceps, suprailiac, and medial calf were those of the five 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. 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 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 the others (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 regions). A single observer will become quite consistent in terms of his or her own technique, and self-replication will be quite high.

Suprailiac and medial calf replication is also related to observer number. The suprailiac skinfold displays, in some cases, extremely high values in certain individuals, and slight differences in individual techniques may cause significantly poorer replicates between observers.

The medial calf skinfold is technically the most difficult of the five to measure. In addition, as with the suprailiac, its values may be quite large. Therefore it is subject to significant inter-observer error.

On the other hand, such individualized techniques are not as important for the subscapular and midaxillary skinfolds 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, 10.5 mm. for the subscapular and midaxillary folds, 13.5 for the suprailiac, and 16.0 for the medial calf fold. These errors remain as residuals despite the careful quality control exercised throughout Cycle 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 and midaxillary skinfolds regardless of whether one or several observers are utilized. Such is not the case for the triceps, suprailiac, or medial calf, 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 other three skinfolds, the situation is more complex. If the purpose is to estimate their distributions 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 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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