Data from the
NATIONAL HEALTH SURVEY

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Number 124

Height and Weight of Youths 12-17 Years United States

Height and weight measurements of youths 12-17 years of age in the United States, 1966-70, are presented and discussed by age and sex, with special attention to the adolescent growth spurt.

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

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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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HEIGHT AND WEIGHT OF YOUTHS 12-17 YEARS

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

INTRODUCTION

This report of data on measurements of height and weight of youths 12-17 years of age from Cycle III of the Health Examination Survey is the first in a series of reports presenting analyses and discussion of body measurements performed in Cycle III. This series will parallel that from Cycle II on children 6-11 years of age on body measurements of heights, weights, skinfolds, and more than 20 other body dimensions related to variables such as age, sex, race, geographic region, socioeconomic level of family, IQ, self-concept, school achievement, and skeletal age.

Cycle I of the Health Examination Survey (HES), conducted from 1959 to 1962, obtained information on the prevalence of certain chronic diseases and on the distribution of some anthropometric and sensory characteristics in the civilian noninstitutionalized population aged 18-79 years of the continental United States. The general plan and operation of the survey and of Cycle I are described in two previous reports[1,2] and most of the results are published in other PHS Publication 1000-Series 11 reports.

Cycle II of the HES, conducted from July 1963 to December 1965, involved selection and examination of a probability sample of noninstitutionalized children aged 6-11 years in the United States. This program succeeded in examining 96 percent of the 7,417 children selected for the sample. The examination focused on two areas: factors related to healthy growth and development as determined by a physician, a nurse, a dentist, and a psychologist; and a variety of somatic and physiologic measurements performed by specially trained technicians. The detailed plan and operation of Cycle II and the response results are described in PHS Publication 1000-Series 1-Number 5.[3]

HES Cycle III, conducted from March 1966 to March 1970, was essentially an age-wise extension of Cycle II and filled in the age gap 12-17 years in the span 6-79 years examined in Cycles I, II, and III during the years 1959-70. As described in detail in "Plan and Operation of a Health Examination Survey of U.S. Youths 12-17 Years of Age,"[4] Cycle III was more similar to Cycle II than it was to Cycle I, not only in form, content, and style, but also in its major emphasis on factors of normal growth and development rather than chronic disease. In fact, the identical primary sampling units that had been used in Cycle II about 3 years earlier were used in Cycle III.[b] The result was that over 30 percent of the youths examined in Cycle III had been examined as children in Cycle II 3 years earlier. By examining 2,000 of the children at two different points in time, it was intended to provide a quasi-longitudinal aspect to these two sequential cross-sectional surveys. However, this

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[b]In Cycle II two separate caravans were in operation simultaneously for the first 25 locations; the two were then consolidated into one caravan for the remaining 15 locations. In Cycle III only one caravan was used for all 40 locations which created a somewhat different itinerary or sequence of locations around the United States even though the identical sites and even primary sampling units were used again. The average time interval between revisits to the same locations was about 3 years.

more complex quasi-longitudinal analysis will be reserved for future reports on body composition and body proportion; in this report the data are handled in the more familiar cross-sectional mode.

This report is confined to analysis of data on height and weight by chronologic age and by sex. Subsequent reports will cover analyses by race, geographic region of the United States, and socioeconomic level of family, and some will correlate height and weight data with "biologic age,"[c] other body dimensions, and with physiologic and behavioral variables. The present report limits the classifying variables to age and sex so that the most important and dramatic event of this age span can be seen clearly—the *adolescent growth spurt.*

The adolescent growth spurt presents a problem in the interpretation of population data which is so important and fundamental that it cannot be overstressed: because every individual has a growth spurt that is somewhat different in time of onset, intensity, and/or duration from that of almost all other individuals, everyone is more or less out of phase with everyone else in reference to chronologic age, which is used so prominently as a group classifier. As can be seen in figure 1, this results in the statistics of the group being distorted, i.e., the growth spurt curve describing the cohort at a cross section in time is flattened in rate of change and broadened in duration compared to the average of the rate and duration of each of the individuals (the latter data can be obtained only in a longitudinal study). This problem will be examined further in both the Results and the Discussion sections. It cannot be overlooked.

Parallel to the pattern developed in the series of reports on body measurements of children 6-11 years, the reports on body measurements of youths 12-17 years subsequent to this one will become increasingly analytic. In this report the data are presented by percentile distributions and by mean, standard deviation, and standard error of the mean. The subjects are grouped by whole-year, half-year, and quarter-year intervals in an attempt to reach a balance point between increasing "statistical noise" resulting from increasingly small samples, on the one hand, and the finest precision in pinpointing a major deflection of a curve or the crossing of two curves, on the other hand.

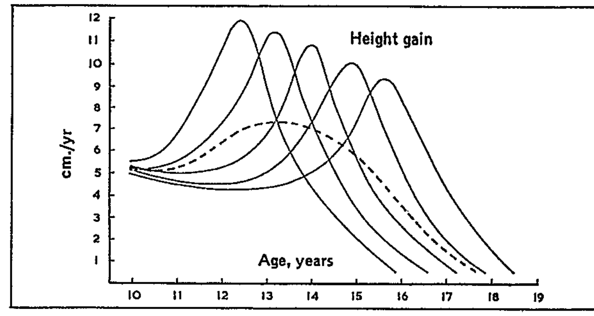

Figure 1. The individual height velocity curves of five boys (solid lines) with the mean curve (broken line) of the average of the individual values at each age. (Tanner, 1966,[5] from a technique by Shuttleworth, 1957,[6] as first suggested by Boas, 1892[7]).

METHOD

At each of 40 preselected locations throughout the United States (appendix I), the youths were brought to the centrally located mobile examination center for an examination which lasted about 3½ hours. Six youths were examined in the morning and six in the afternoon. Except during vacations, they were transported to and from school and/or home.

When they entered the examination center, the youths' oral temperatures were taken and a cursory screening for acute illness was made; if illness was detected, the youth was sent home and reexamined later. The examinees changed into gymnasium-type shorts, cotton sweat socks, a terry cloth robe (for the girls), and a light sleeveless topper; all six then proceeded to different stages of the examination, each one following a different route. The 3½-hour examination was divided into six 35-minute time periods, each consisting of one or more detailed examinations at a designated station.[d] At the end of each period the youths rotated to an-

[c]Skeletal age by X-ray and maturation level of primary and secondary sex characteristics assessed by the examining physician.

[d]The entire examination by the psychologists consisted of two consecutive time periods (70 minutes). Both of the psychologists performed identical examinations simultaneously at separate stations.

other station so that at the end of 3½ hours each youth had had essentially the same examinations by the same examiners but in a different sequence. Four of these examination time periods were allocated to examinations by a pediatrician, a dentist, and a psychologist, and the other two were allocated to a group of examinations performed by highly trained technicians. This last group of examinations consisted of X-rays of the chest and hand-wrist, hearing and vision tests, measures of respiratory function, a 12-lead electrocardiogram, a submaximal exercise tolerance test on a treadmill with chest leads to a continuous electrocardiogram, a battery of body measurements, grip strength, examination of blood and (on girls only) urine cultures for bacteria, and a privately administered health behavior and attitude questionnaire.

The measurements of height and weight were obtained exactly as described for children 6-11 years of age.[8]

Height

Height was measured in stocking feet, with feet together, back and heels against the upright bar of the height scale, head approximately in the Frankfort horizontal plane ("look straight ahead"), and standing erect ("stand up tall" or "stand up real straight" with some assistance and demonstration when necessary).[e] However, upward pressure was not exerted by the examiner on the subjects' mastoid processes to purposefully "stretch everyone in a standard manner" as is recommended by some.[9] It is reported that supine length, that is, the recumbent position which relieves gravitational compression of the intervertebral spaces, yields 2 centimeters (cm.) greater length (height) and that height with the "upward pressure technique" measures 1 centimeter greater than with HES technique.[10]

The equipment consisted of a level platform to which was attached a vertical bar with a steel tape. Attached perpendicularly to the vertical bar was a horizontal bar, which was brought down snugly on the examinee's head. Attached to another bar in the same plane as the horizontal measuring bar was a Polaroid camera which recorded the subject's identification number next to the pointer on the scale giving a precise reading. The camera, of course, not only gave a permanent record minimizing observer and recording error, but by sliding up and down with a horizontal bar and always being in the same plane, it completely eliminated parallax. That is, if the pointer had been in the space in front of the scale, it would have been read too high if the observer had looked up at the scale from below, or too low if read down from above.

Weight

A Toledo self-balancing weight scale that mechanically printed the weight to a tenth of a pound directly onto the permanent record was used. This direct printing was used to minimize observer and recording errors. The scale was calibrated with a set of known weights and any necessary fine adjustments were made at the beginning of each new trailer location, i.e., approximately every month. The recorded weight was later transferred to a punched card to the nearest 0.5 pounds (lb.). The total weights of all clothing worn ranged from 0.24 to 0.66 lb.; this has not been deducted from weights presented in this report. (The weights, then, are 0.24–0.66 lb. above nude weight recorded to the nearest 0.5 lb.) The examination clothing used was the same throughout the year so there is no seasonal variation in the weight of clothing. These efforts in quality control appear justified by the excellent level of reproducibility (see discussion of replicate studies in appendix III).

Age

As in all HES reports, age is basically defined as age attained at last birthday (verified by birth certificate in 92 percent of the Cycle III examinees). In all tables utilizing whole-year age groupings, the designated age represents the beginning of the interval and not the mean age of the group (i.e., "15 years" means 15.0–15.99 years). However, when the population is divided into half-year and quarter-year age groupings, the designated age is the approximate mean of

[e]This is the standard erect position described by Krogman.[10]

the age grouping (e.g., the group designated 15½ years in table 3 includes all those youths 15½ years ±3 months or 15.25–15.74 years with actual mean age of 15.49 for the boys and 15.51 for the girls; and 15¼ years in table 5 designates those youths 15¼ ±6 weeks with an exact mean of 15.25 for both boys and girls.

In Cycle II of the HES, children were selected for inclusion in the sample if they were between the ages of 6 and 12 years at the time of the initial household interview. In Cycle III, the subjects selected for inclusion were between 12 and 18 years of age at the time of the initial interview. However, at the time of the examination these youths were actually from several days to several weeks older than when selected for the study (this is reflected in the average ages of tables 1, 3, 5, etc.). For both half-year and quarter-year breakdowns, except for the first and last categories, the actual mean age in each category is very close to the midpoint of the age interval. However, because there were no children younger than 12 at the time of examination to make 12 the midpoint, the category "12 years" includes only those children between 12 and 12¼ for the half-year break and between 12 and 12 1/8 for the quarter-year break. Similarly, for the 18-year-old category, even though the mean was closer to 18 for this group than was 12 for the 12-year-old category, the actual average age is low because children were not old enough at the time of the examination to make the distribution about 18 years symmetrical.

This report initiates the inclusion of data from a previous HES cycle. In all earlier HES reports, the data from each cycle were handled as a discrete unit. However, the overlapping sampling design and similar methodology of Cycles II and III enable the height and weight data of children 6-11 years to be incorporated in many of the figures and some of the tables in this report to give a much better perspective of the adolescent growth spurt by describing the 12-year span, 6-17 years, rather than limiting ourselves to ages 12-17.[f]

[f]As will be seen, in several minor instances, data were incorporated from Cycle I on adults 18-34 years for estimating final adult size, but with neither the same ease nor sense of confidence of comparability. This procedure is described in appendix II, B.

The addition of the 6-11 year age group and the use of finer age breaks create minor complications. The first is that when the data were grouped by half- or quarter-year age intervals there was overlapping between the oldest group from Cycle II and the youngest from Cycle III (both called "12 year olds"). As discussed above, the Cycle II 12 year olds actually had a mean age less than 12.0 years whereas the identically labeled group from Cycle III had a mean age greater than 12.0 years. However, when the two means were combined to form one weighted mean for the two cycles together for 12 year olds, they balanced each other well enough so that the resultant new mean is quite accurately centered. The second is that one or two age groups are lost at both the beginning and end of the age distribution wherever the data have been smoothed by the moving average technique (as described in appendix I) when the half-year and quarter-year age groupings are used. This results in the following uses of data points for graphing and for analysis: (1) Data grouped by whole year: the midpoint of each age interval is used, 6.0, 7.0 ... 11.0; 12.0, 13.0 ... 17.0, that is, 6.5 ... 11.5; 12.5 ... 17.5. (2) Data grouped by half-year age intervals: (a) unsmoothed would give the same groups as above, 6.5 ... 11.5; 12.5 ... 17.5, but (b) when *smoothed* by a three-period average, the end group at either end is lost, so for all the data cited in this report by half years, the groups are 7.0, 7.5 ... 11.5; 12.0, 12.5 ... 17.0. (3) Data grouped by quarter-year intervals: would have given 6.25 ... 11.75; 12.0, 12.25 ... 17.75, but two age groups are lost at each end in computing the five-period moving average for these data (as described in (2), above), so the effective groups are 6.75 ... 17.25 or 12.75 ... 17.25.

RESULTS

Height

Table 1 presents the frequency distribution of heights in centimeters for boys and for girls, grouped by whole-year age intervals, together with the mean heights, standard deviations, standard errors of the mean, the unweighted sample size, average age of youths in each group, and seven selected percentiles of U.S. youths 12-17 years of age for 1966-70. Table 2 includes some of these same data, again by whole-year age intervals, but in inches. Table 3 gives the mean heights and percentiles in centimeters for the youths grouped by half-year age intervals, while table 4 presents the same data in inches rather than centimeters. Table 5 provides the data (in centimeters) similarly, but divided into quarter-year age groupings.

Distance curves, or attained height curves, can be constructed from the data in the tables by plotting the points, and the points can then be connected if the following condition is recognized: strictly speaking, a distance (or attained size) curve is the charting of an individual's attained or accumulated size (or the mean of a group) at any given point in time. To be epidemiologically scrupulous, this would have entailed serial measurements taken at 3-month intervals ($\pm$just a few days) of *each* of the 6,768 youths at ages 12.0, 12.25, 12.50, 12.75, 13.0, 13.25 ... 14.0 ... 18.0 years (25 x 6,768 = 169,200 measurements). But, on the basis of two major assumptions, the HES was designed not only to surmount this logistic nightmare but that of sampling as well: to achieve the equivalent of these numerous seriatim measurements on a cohort of youths who represent 3,782,000 children starting at age 12 years as they moved through the 6-year span (i.e., one-sixth of the 22,692,000 total noninstitutionalized youths 12-17 in the United States in 1966-70). The first assumption is that nothing like war, pestilence, or famine occurred in the 18-year duration (the time it took the oldest segment of the 12-17 year old cohort to attain 18.0 years from birth). Because, if one of these cataclysms had occurred, it would have affected the disparately aged members of the 6-year cohort at different stages of their individual growth process and it could not be assumed that children 13 years of age at the time of the study would have the same growth characteristics as those 14 years or 16 years old at the time of examination. In other words, it must be reasonable to assume that since none of these disasters did occur, all of the different age groups of children within this 6-year-age HES sample will have had common growing conditions. Of course, this assumption could not be made for the much larger age groupings in Cycle I adults because those who were in the age group 18-24 years in 1960-62 were all born after the worst part of the Great Depression, whereas those 25-34 years had been at their most critical stages of growth during the Depression (i.e., prenatal, infancy, early childhood years), and those 75-79 years had finished most of their growth before the majority of the dramatic 20th-century advances in environmental hygiene, pediatric medical care, and nutrition had occurred.

The second assumption is, of course, that the Cycle III HES sample which was actually examined is in fact representative of the much larger universe from which it was drawn.

If these two assumptions are valid, all of the HES "growth attained," or distance, curves are solid estimates. Tanner estimates the statistical power of distance curves obtained from longitudinal data to be 20 times that of curves obtained from cross-sectional data such as these.[11] Even though they are more statistically elegant and conceptually impeccable, all the curves generated from longitudinal studies are confronted by the gulf of extrapolation—that is, the great guessing game of getting from the specific group of people studied to the desired referent population. The HES sample not only statistically overwhelms the initial 20-to-1 disadvantage referred to above by expanding its population approximately 3,500 times (i.e., 6,768 to 22,692,000), but it also bridges the sampling abyss to the much larger and much better known actual referent population (i.e., all those 22,692,000 noninstitutionalized youths between the ages of 12.0 and 18.0 years in the United States, 1966-70).

Granting these conditions, five different distance curves for height were constructed and examined by using not only these Cycle III data but also, to gain a much better perspective, the correlative data from Cycle II on children 6-11 years. Three curves were constructed from the data of the 1-year, half-year, and quarter-year age groupings in the tables, and, to reduce the "noise" (or statistical aberrations due to increasingly small sample sizes), the other two used the data from the half-year age groupings which were smoothed by a three-period moving

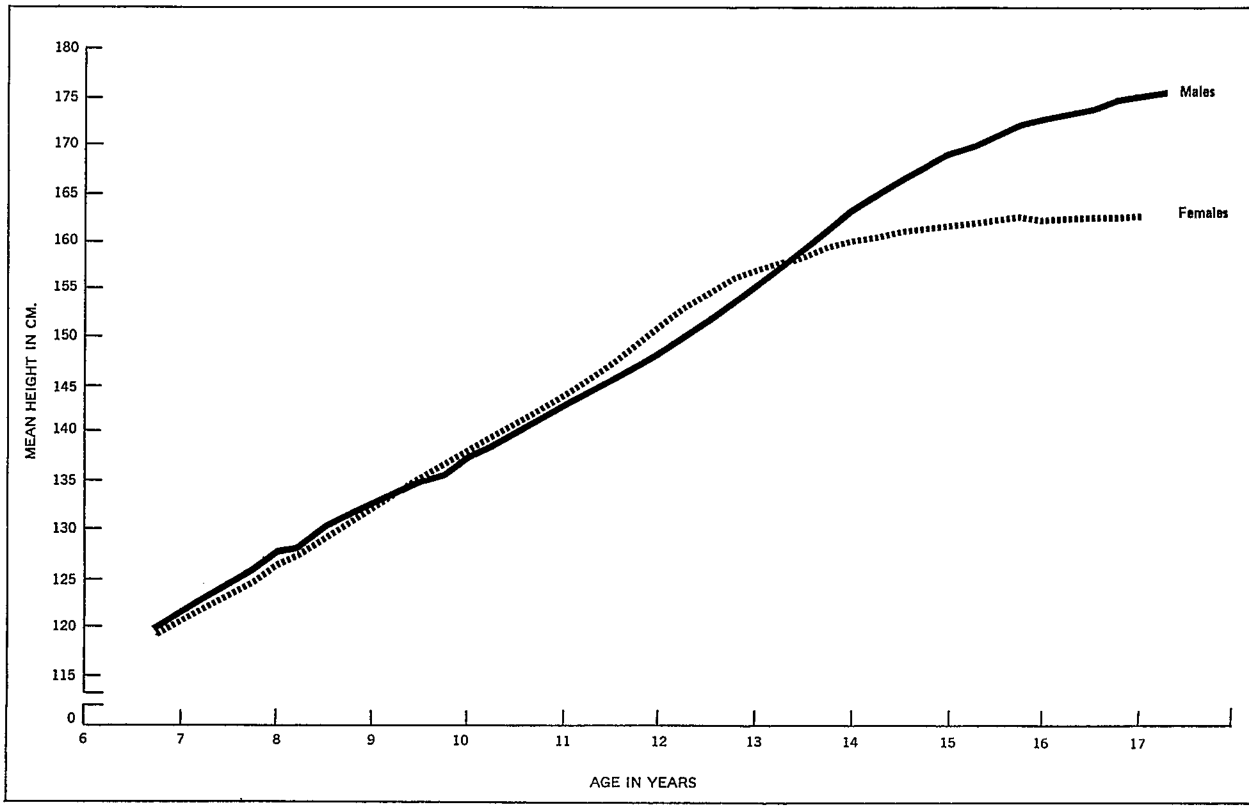

Figure 2. Distance curve of mean height attained by U.S. youths 6-18 years of age by quarter-year age groups smoothed by a five-period moving average.

average (table 6) and those from the quarter-year group (table 7) smoothed by a five-period moving average. The unsmoothed half-year and quarter-year graphs were discarded almost immediately because they were too "noisy." Although each of the three remaining graphs is useful (as described in appendix II,A), figure 2, the curve constructed from quarter-year-age groups and then smoothed by the five-period moving average (table 7) was selected as the overall "best," i.e., the most sensitive to detect changes and to accurately time major events yet free enough from noise to be readable.

The first part of both the boys' and girls' curves in figure 2 is quite linear until about 10½ years for girls and about 12 years for boys at which time the curves start an upward deflection.[g] This deflection steepens for about 1½ years, then increasingly tapers off until it becomes horizontal for girls by age 15¾ and only slightly above the horizontal for boys at the last point, age 17¼ years. The other outstanding feature is that the two curves cross each other twice, that is, boys start out slightly taller but

[g]This is oversimplified. To be strictly accurate, this sentence should have read: "The line connecting the smoothed means of the successive quarter-year age samples of children is essentially linear between 6½ years and 10½ years in girls and between 6½ and 12 years in boys. The mean heights of the children in the successive quarter-year age samples after these ages become increasingly larger, etc." For economy of wording, the metaphorical will be used frequently throughout, that is, the curves will be described as if they are true growth curves or describing movement over a period of time.

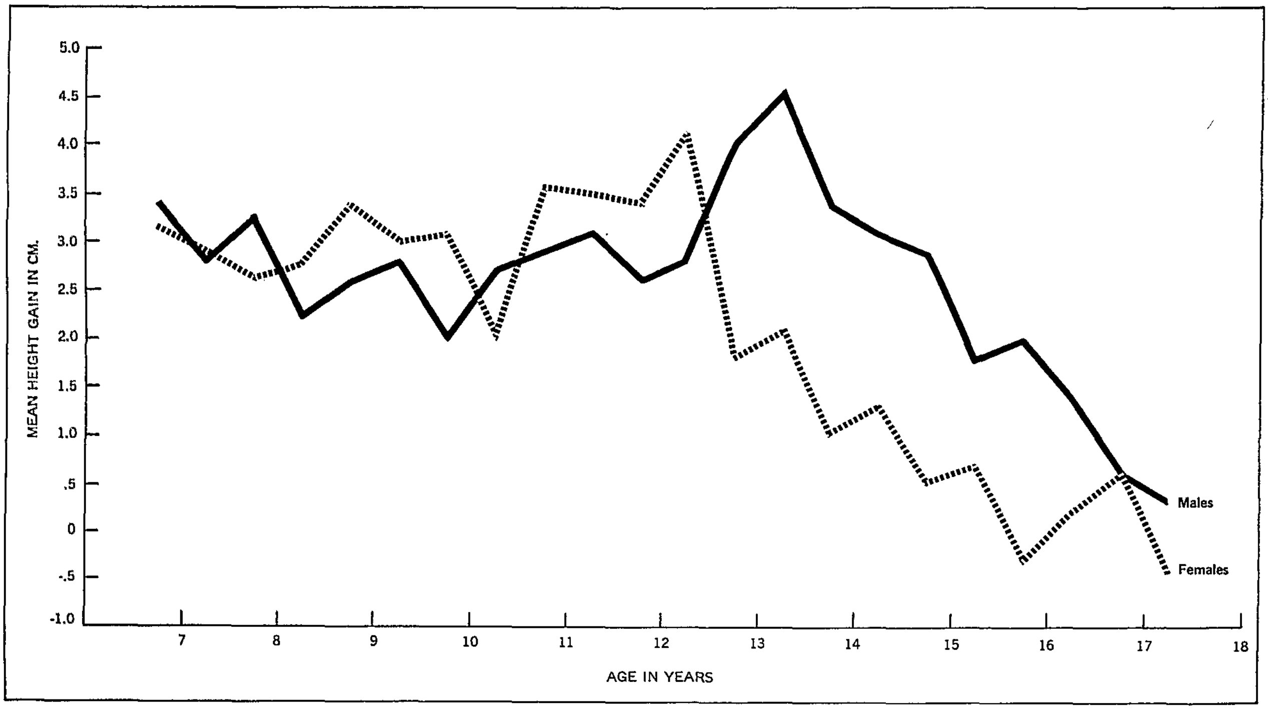

Figure 3. Pseudo-velocity curve of differences in mean heights between successive groups of U.S. youths 6-18 years of age by half-year age groups.

girls become taller at 9¼ years and remain so for the next 4 years until the boys rather dramatically pass the girls at 13¼ years[h] and continue to widen the gap for the remaining 4 years.

From age 6 through age 17 in boys and to age 16 in girls each age grouping of children is taller than the previous age group. Table 6 presents the difference in mean heights between each successive pair of half-year age groups of children 6-17. It also presents the mean heights smoothed by a three-period moving average and the differences between these smoothed means. Table 7 is a similar presentation for quarter-year age groups smoothed by a five-period moving average. Figure 3 graphs the differences between the means of the half-year age groups *unsmoothed* from table 6, figure 4 graphs the differences between the *smoothed* mean heights also from table 6, and figure 5 graphs the differences between the smoothed means of quarter-year age groups from table 7. The three graphs illustrate the effect of smoothing by use of moving averages[i] as well as the effect of shortening the age interval. In general, it can be seen that figure 3 has noise without as much precision as the others (i.e., the points are rather

[h]These specific chronologic estimates, as do all the succeeding ones, represent summary estimates—or best educated guess—arrived at after months of trial and error and "living with the data." A systematic description of how these "best" summary estimates were achieved is presented in appendix II.

[i]The rationale and technique used for smoothing by moving averages are discussed in appendix I. The incremental curves are more erratic than distance curves and require smoothing principally because the vertical axis is 10 times as sensitive (the entire range of the vertical axis for velocity curves of figure 3 is one-tenth the total length of figure 2's) so that the growth spurt can be magnified and examined better. In addition, a slight sampling variation in one incremental point, because it increases one interval while reciprocally decreasing the other, makes incremental curves inherently more unstable than directly measured, successively plotted points of distance curves. Also, since it makes no difference whether the means are smoothed first and the differences are taken, or whether the differences are taken of the unsmoothed means first and then these differences later smoothed, the two procedures are used interchangeably. Smoothing by moving averages is not to be confused with hand smoothing by visual inspection to make a "prettier and smoother" curve.

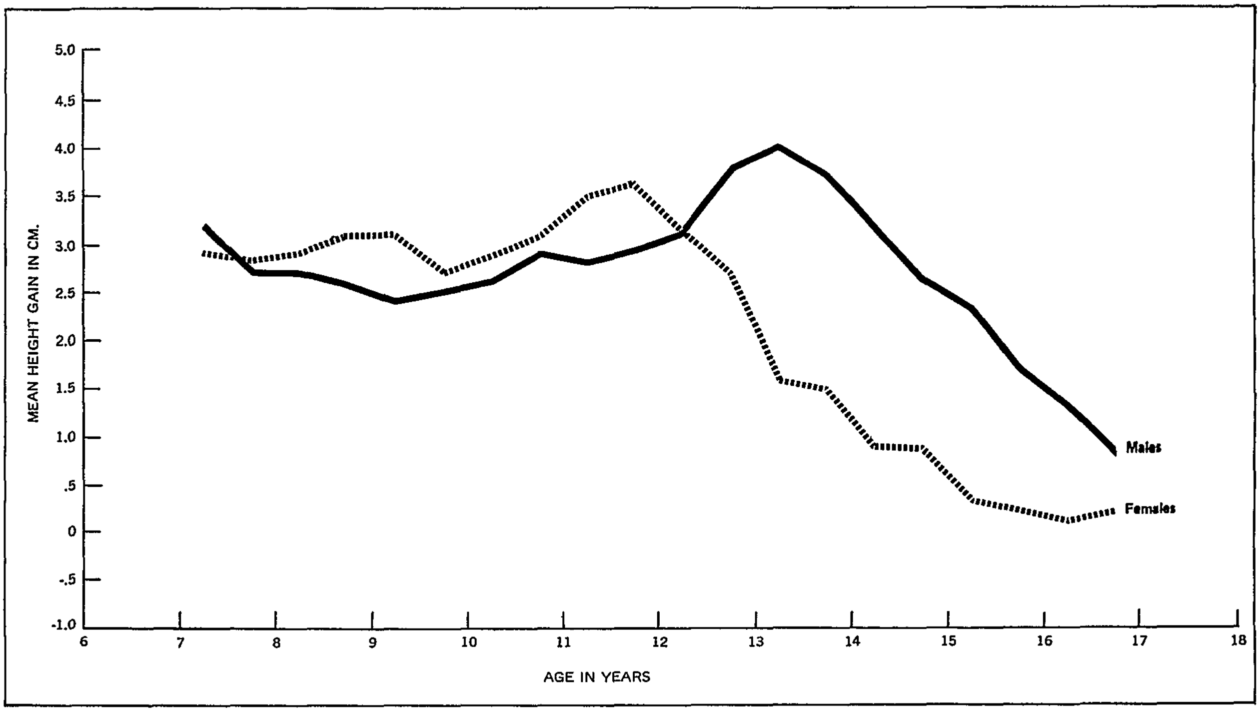

Figure 4. Pseudo-velocity curve of differences in mean heights between successive groups of U.S. youths 6-18 years of age by half-year age groups smoothed by a three-period moving average.

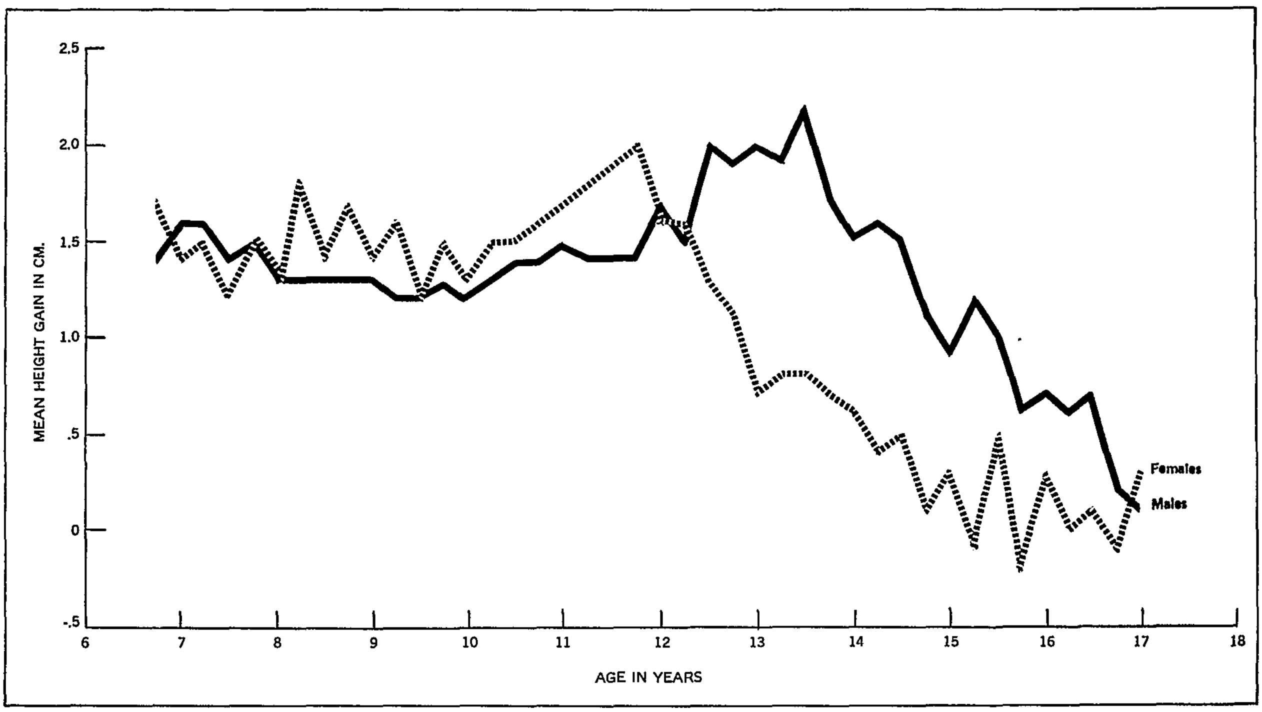

Figure 5. Pseudo-velocity curve of differences in mean heights between successive groups of U.S. youths 6-18 years of age by quarter-year age groups smoothed by a five-period moving average.

erratic and the jumps are larger); the data in figure 5 have increased the precision by cutting in half the distance between plotted points without increasing the "noise level" much; but figure 4 was chosen as the one having the best overall balance between noise and precision. Although figure 4 is used as the single best curve for general illustrative purposes and for chronologically locating the onset, peak height, and ending of the growth spurt, the other two graphs help clarify several equivocal points, as will be seen shortly.

Growth curves, or velocity curves, i.e., rates of increment, can be constructed on individual children from serial measurements taken from birth to adulthood (or from shorter time segments). When hundreds of carefully obtained individual growth curves are examined, it can be seen that while each one is somewhat different from every other one, there is enough similarity so that a sense of pattern emerges. These individual differences are not quite so important during the long, rather stable childhood growth period from about age 3 or 4 to about age 10 or 11. During this time, a fitted straight line best describes the velocity curve. But as already illustrated in figure 1 and to be discussed in detail later in this report, these differences of phasing (or individual differences in chronologic timing) of growth spurts can cause serious misinterpretations of grouped data (whether longitudinally or cross sectionally obtained) unless suitable adjustments are made.

With a renewed warning to draw inferences only with caution, figure 4 (the curve described by joining plotted points from table 6) can then be used as our best pseudo-velocity curve. In addition, the "pseudo" label will continue to be used as a further caution because the metaphorical shortcuts are used throughout the rest of the report.

The general shape of figure 4 shows that between the ages of 7 and 10½ for both boys and girls the differences between successive age cohorts are relatively constant, falling between 4.8 and 6.4 cm. per year for boys and between 4.8 and 7.2 cm. for girls. For boys the greatest mean change occurs at 13¼ years while for girls, the peak is at 11¾ years. After they reach this summit, the differences between successive ages decrease—this decrease occurs earlier and a little more abruptly for girls than for boys.

All three graphs (figures 3-5) show that the mean peak of the pseudo-growth spurt of boys is higher than that of girls, the difference appearing a bit greater in figure 3 because it was not smoothed. However, the exact magnitude of the pseudo-peak growth is not important because, as was pointed out in figure 1, the peak of the group average is falsely low and does not accurately describe the average of the individual youth's peaks. On the other hand, the chronologic timing of the peak of the pseudo velocity is quite accurately determined from these HES data. In figures 3, 4, and 5 the peak is found in boys at 13¼, 13¼, and 13 5/8 years, respectively; while in girls it occurs at 12¼, 11¾, and 11 7/8 years.[j] The most accurate estimated points (as described in appendix II) for the chronologic timing of the peaks are 13¼ years for boys and 11¾ years for girls. Girls, on the average, hit their peak rate of growth in height about 1½ years earlier than do boys.

The other area of the growth curves of major interest is the beginning of the growth spurt. The estimated chronologic timing of this event is somewhat earlier from these cross-sectional data than is the beginning, as estimated from true growth curves, i.e., seriatim measures on the individual. Nevertheless, these HES group estimates have value as a compromise because of the technical difficulty in ascertaining the exact onset of the spurt in some individuals when measured only yearly.

As stated above, figure 4 was selected as the "best overall" graph for pseudo-height velocities; however, from this graph alone one would hesitate to pick the onset of the growth spurt with certainty because of the noise in that area. Use of the other graphs (figures 3 and 5) allows one to make "fine-tuning" adjustments as on a radio, and a point becomes clear enough for a reasonable estimate. The point which seemed to best estimate a true deflection was 11¾ years

[j]The detailed description in appendix II summarizes all of the estimated points in tabular form. Whole-year estimates are also included there, but these are more "insensitive" than half-year smoothed or unsmoothed estimates. The values from the whole-year estimates are 13.0 years for boys and 12.0 years for girls.

for boys and 10¼ for girls. The 1½-year sex difference was considered accurate for the two peak velocities; so if there is consistency between the age at the start of the spurt and the age at reaching the peak velocity, then 10¼ years would be the best estimated time for enough girls to have started their growth spurts (to varying degrees) and to have caused an upward deflection in the average pseudo-velocity curve.

To complete the observations on these pseudo velocities, the end of the growth spurt together with a derived dimension—the duration of the growth spurt—will be considered briefly. Just as the onset of the spurt was determined by fitting a line through the stable years from 6 until about 11 years and estimating the point at which the curve deflects upward, for this report the end of the spurt is determined by the point at which the descending curve intersects that relatively stable line extended horizontally, i.e., when the pseudo velocity falls below the last stable childhood rate. The best point estimate for the end of the growth spurt is 14½ years for boys and 12½ years for girls. Consequently, the duration of the spurt in height is 2¾ years for boys while only 2¼ years for girls.

Weight

The data on weight measurements are presented and analyzed tabularly and graphically in a manner parallel to that just followed for the height data. Table 8 presents the frequency distribution of weight in kilograms for boys and for girls, grouped by whole-year age intervals, together with the mean weights, standard deviations, standard errors of the mean, the unweighted sample size, average age of youths in each age group, and seven selected percentiles of United States youth 12-17 years of age for 1966-70. Table 9 presents the mean weights, standard deviations, standard errors of the mean, and percentiles for weight in pounds. Table 10 gives the mean weights and percentiles in kilograms for the youths grouped by half-year age intervals, and table 11 provides the same data in pounds rather than kilograms. Table 12 uses a similar format, but the data are further divided into quarter-year age groupings. Table 13 pre-

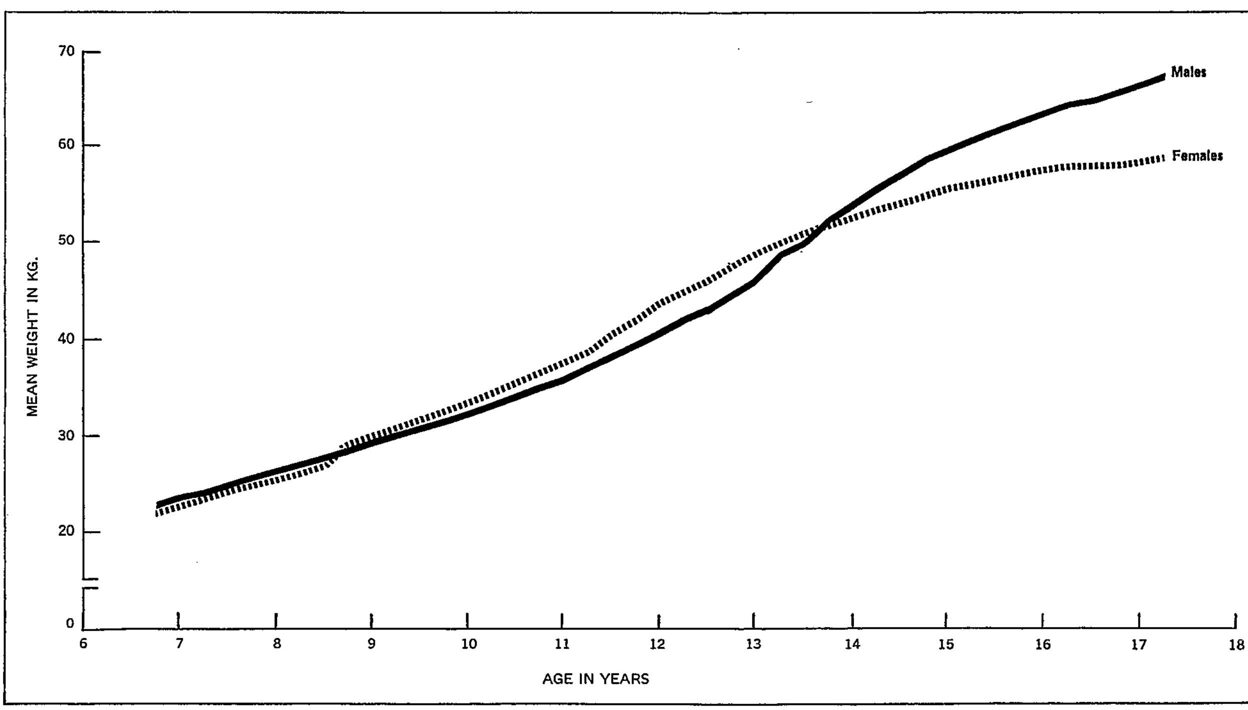

Figure 6. Distance curve of mean weight attained by U.S. youths 6-18 years of age by quarter-year age groups smoothed by a five-period moving average.

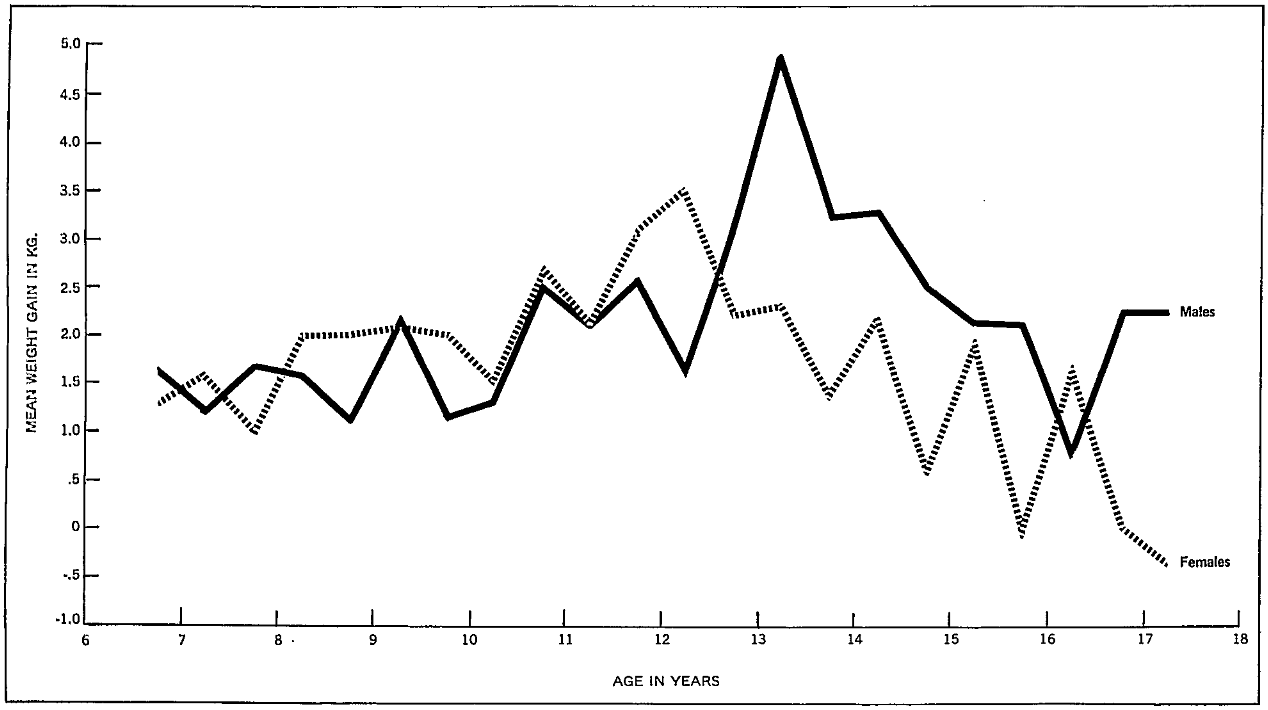

Figure 7. Pseudo-velocity curve of differences in mean weights between successive groups of U.S. youths 6-18 years of age by half-year age groups.

sents the differences between the mean weights (first unsmoothed and then smoothed by a three-period moving average) for half-year age groups in the same way as table 6 did for height data, while table 14 uses the same procedure with quarter-year groupings, but smoothed by a five-period moving average (identical in format to table 7).

Figure 6, which graphs the attained mean weights of the samples of youths by quarter-year intervals smoothed by a five-period moving average (table 14), was chosen as the prototype for weights as figure 2 was for heights. Although the general shapes of the curves are similar to those in figure 2, they are not quite as smooth and the curve for the boys does not suggest much tapering off at the end. The crossings of the curves of mean weights for the two sexes occur at 8¾ years (it was at 9¼ years for heights) and again at 13 5/8 years (it was at 13¼ for heights). Girls, then, are heavier than boys on the average for almost 5 years (compared with being taller for 4 years).

In the pseudo-velocity curves for weight (figures 7, 8, and 9), there is more noise than there is in the corresponding height graphs, indicating a greater variability of the groups by weight than by height. Although a straight line can also be fitted as it was for height, the fit is less good. Furthermore, in the early years the velocity of weight increase constantly increases—although only slightly until the growth spurt—whereas the height incremental velocity is essentially horizontal. Also, the peak velocity of weight increase is not quite as well defined and is broader. Perhaps the most striking sex difference between the incremental patterns of height and weight is the divergence between boys and girls by weight at ages 17-18. In height the girls have already stopped and the boys are approaching a zero increment, but for weight the last group of girls has almost stopped[k] whereas the boys are still gaining weight. In addition, the peak weight velocity of the boys

[k]By the graphed moving average technique the last few age groups are lost (see page 4 of text and appendix I). However, the actual (unsmoothed) measurements from tables 10, 11, and 12 demonstrate that girls not only stopped gaining weight but might be losing a bit on the average.

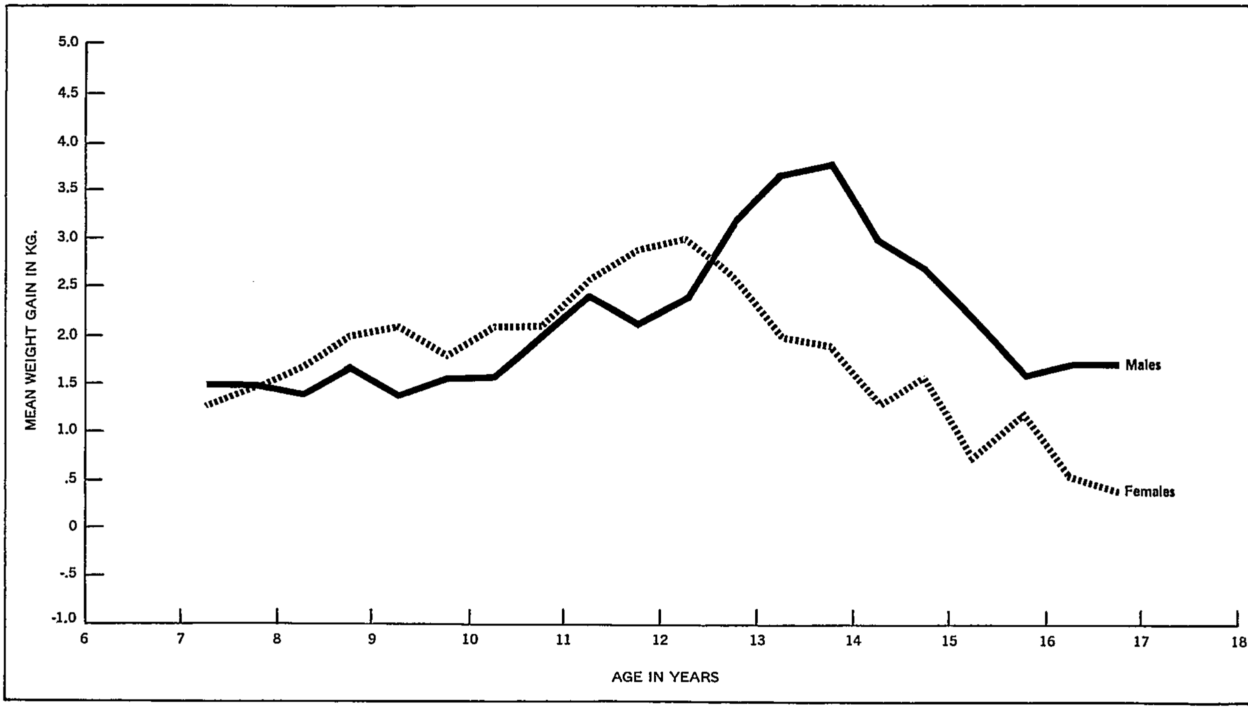

Figure 8. Pseudo-velocity curve of differences in mean weights between successive groups of U.S. youths 6-18 years of age by half-year age groups smoothed by a three-period moving average.

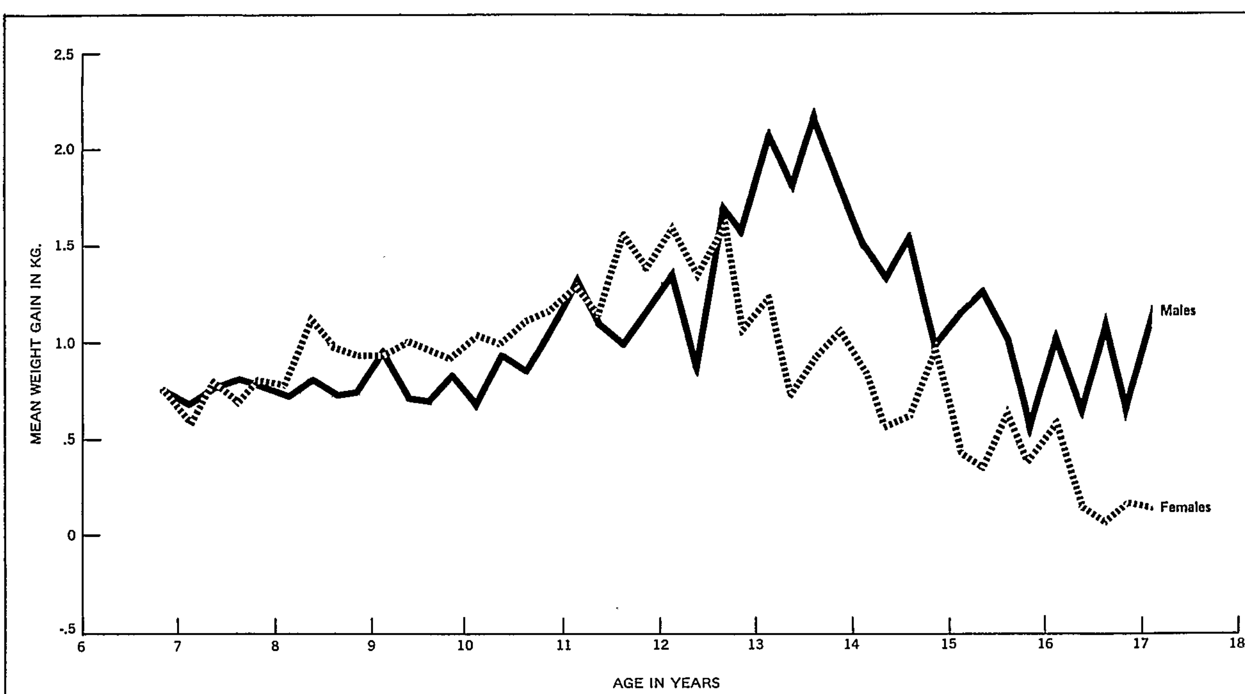

Figure 9. Pseudo-velocity curve of differences in mean weights between successive groups of U.S. youths 6-18 years of age by quarter-year age groups smoothed by a five-period moving average.

appears greater than the girls' peak weight velocity, and this margin of difference is greater than the boys' margin over girls in peak height velocity.

The best estimates of timing the beginnings and the peaks of the weight spurts are as follows: onset for boys at 12¼ years, for girls at 10¾; and peak velocity for boys at 13¾ years, 12¼ for girls. These estimates produce a consistent difference of 1½ years by which the girls reach both the onset and the peak velocity sooner than the boys for height and for weight; however, both of these events occur one-half year later for weight than for height.

The mean durations of the height and weight spurts are almost identical. In males both height and weight spurts last 2¾ years whereas in females the weight spurt lasts 2½ years and the height spurt, 2¼ years.

Summary of "Best HES" Estimates of Growth Spurt Parameters from the Pseudo-Velocity Curves

	Start	Peak	End	Duration
		Height		
Boys	11¾	13¼	14½	2¾
Girls	10¼	11¾	12½	2¼
		Weight		
Boys	12¼	13¾	15	2¾
Girls	10¾	12¼	13¼	2½

DISCUSSION

Adolescent Growth Spurt

The adolescent growth spurt is a unique and dramatic feature of human growth. The striking increase of the growth rates in both height and weight, which for individual children may double and then decrease to the original values in only 2 years, suggests an addition of tissue at an intensity unequaled at any other time after birth except in the immediate postnatal months. In fact, Heald[12] points out that adolescence is the only time since leaving the uterus that the human organism increases its rate of growth.

Not only is the growth spurt of significance because of its influence on the ultimate adult dimensions, it is of phylogenetic importance because some experts conclude that although all mammals have a pubescence (i.e., achieve sexual potency), an adolescent somatic growth spurt is unique to the human species. The studies of Gavan and Swindler,[13,14] for example, failed to detect any adolescent spurt in the growth rates of other primates, nor is any noted by those primatologists whose reports have been summarized by Watts.[15] However, Tanner believes that seals, and perhaps other nonprimates, have a true adolescent growth spurt.

Therefore, it is not surprising that a great variety of laboratory, clinical, and epidemiologic studies attempting to document and understand human growth during adolescence have been conducted. The measurements of the heights and weights of hundreds of various samples of children from many parts of the world have added much to a descriptive knowledge of the somatic changes during this period of development.

On the other hand, surprisingly little is known of the expected duration or intensity of the growth spurt among individual children despite the mass of data noted above. Unfortunately, almost all studies have failed to control for variations in the timing of the spurt among individuals and the indiscriminant grouping by chronologic age of children who are at various stages of adolescent development will not only mask the nature of this phenomenon but will also yield falsely low estimates of its magnitude.

As an example, consider the curve depicted in figure 10; this shows the average rate of growth in height, expressed in centimeters per year, for a longitudinally studied sample of well-nourished American and Western European children attending the American School, a private school in Guatemala City.[16] The data points represent the mean growth rates over 1-year periods calculated from serial measurements of the children at annual intervals. The adolescent spurt is clearly visible and an average maximum rate of 6.7 cm./yr. may be noted at 13½ to 14½ years of age; in addition, the age range between the first upward deflection of the curve and its return to the rate at this age is about 6 years (i.e., 9½–15½ years of age).

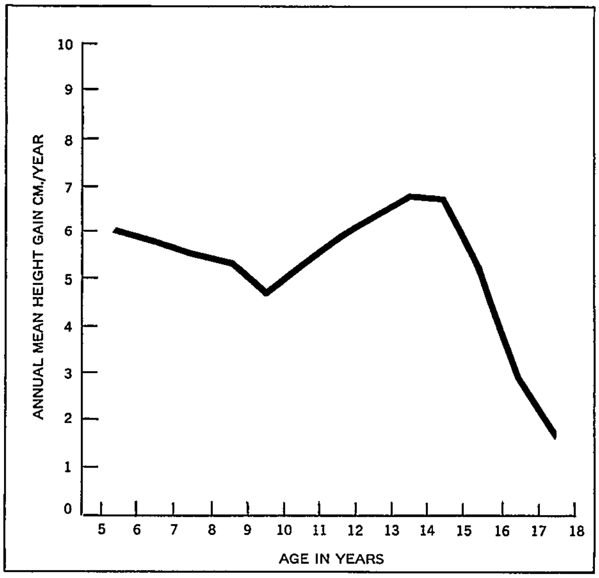

Figure 10. Mean rates of growth in height from the annual measurements of 40 boys from the American School in Guatemala City.[16]

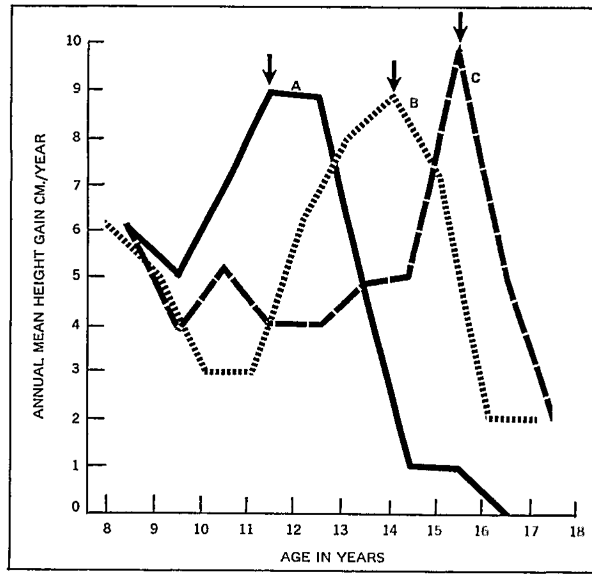

Figure 11. Individual height velocity curves of three boys from the American School in Guatemala City.[16] Boy A: Early maturer; Boy B: Average maturer; Boy C: Late maturer. The arrows indicate peak height velocity (PHV).

The data of figure 10 do not give an accurate representation of the adolescent spurt of any individual because any single age group will consist of children who vary considerably as to their particular stage of adolescence. At the same chronologic age, e.g., 14 years, some are beyond their peak velocity and will be decelerating rapidly, others will be accelerating to their peaks, while still others will have already completed their growth spurt and a few will not yet have begun their own spurts.[16] Most of this variation is illustrated in figure 11 which shows the records of three boys of the Guatemalan sample who experienced their peak height velocities at different ages covering a 4-year range. Before the growth spurt little difference is noted but marked variation is obvious afterward, due to differences in the timing of the spurt. As Tanner has pointed out using a similar example,[5] merely averaging the velocities at any age is of limited value with respect to the analysis of individual growth. Thus in figure 11, each boy experienced a peak height velocity of 9-10 cm./yr. However, the mean height velocity of the three does not approach such a value at any chronologic age. For example, at 12.5 years the mean velocity is 6.3 cm./yr. and at 14.5 it is only 6.7 cm./yr. Thus to calculate means and to present them as indicative of individuals would result in a curve which is too flat.

In addition, since one of the boys is almost through his spurt before another has really begun, the apparent duration of the spurt, as inferred from the mean velocities of age groups, would be too long.

A number of solutions have been offered to the above problem, none of which is ideal, e.g., Tanner, Whitehouse, and Takaishi.[5] However, if a sufficient sample of longitudinal records which span the adolescent period is available, a method first suggested over 70 years ago by the pioneer anthropologist Franz Boas[7, 17] will yield informative though retrospective results.

Boas' approach, which had been neglected by all but a few later workers (most notably, Shuttleworth[6] and Tanner[5] as mentioned in figure 1), consists of analyzing the records of children who experienced their most rapid growth at similar ages. This may also be accomplished by grouping individuals, not by chronological age, but by the years before or after their peak height (or weight) velocity, i.e., PHV. For the three boys of figure 11, this is illustrated in figure 12 for the year of PHV, the 2 years before, and the 2 years after this milestone. To be sure, individual variability still remains; however, it has now been greatly reduced by eliminating that component of the variability due to differences in timing. Any mean that is calculated on this basis will accurately depict the true average value relative to a particular location on the adolescent growth curve.

The application of this approach to a larger sample may be seen in figure 13, again for the sample from Guatemala City. The PHV of each of the 40 boys, comprising the longitudinally followed group, was calculated separately and then averaged (mean PHV); the average velocities 2 years before and after were likewise determined as was the mean age of attainment of the PHV. These five mean velocities are plotted, for the appropriate ages, in figure 13 and superimposed upon the age-grouped means of figure 10. It is apparent that the PHV-oriented curve, which more accurately represents the growth of individual boys, is both narrower with respect to chronologic age and also more sharply peaked than is the age-grouped curve.

While in theory it might be more desirable to analyze the adolescent phase of growth relative to its onset rather than its peak, it is technically so difficult as to render it virtually

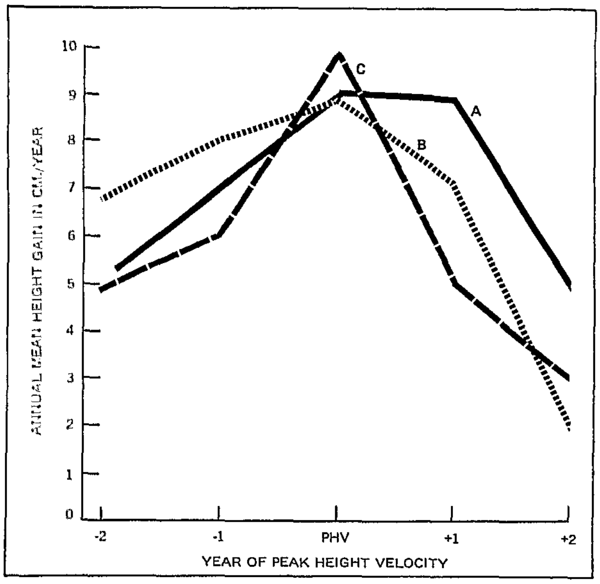

Figure 12. The three boys from figure 11 grouped by years before and years after PHV[16].

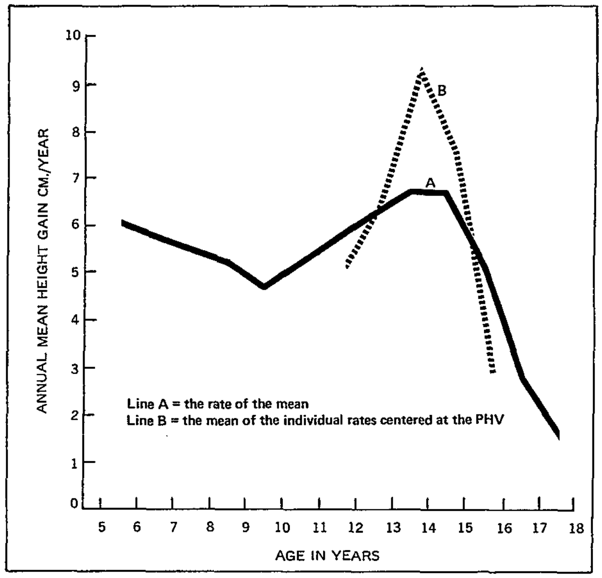

Figure 13. The effect of averaging individual growth rates after centering them at the PHV. Line A is the mean annual increase in height (cm./year), by chronological age, for 40 boys measured annually at the American School in Guatemala (identical to figure 10). Line B is the average of the 40 individual height gain velocities at PHV and at 1 and 2 years before and after the PHV.

impossible. The fluctuations in the rates of growth of individuals (figure 11) make the pinpointing of the beginning of the curve significantly subjective in many cases. The same is true for its completion; some children decelerate rapidly while the velocities of others decelerate slowly. On the other hand, in almost all youths the peak height velocity is a discrete value which may be recognized easily. Weight, of course, is subject to considerable fluctuations even during adolescence because of the effects of dieting or acute episodes of disease.

The calculation of average velocities that accurately reflect individual growth patterns during adolescence requires longitudinal data treated in ways to minimize variability among the subjects in the timing of their spurts. Only with such data can the adequacy of growth in individual children be evaluated. Prior to the onset of adolescence, however, such a stricture is not necessary since the effects of differences in timing are relatively small and the overall trend at that time is essentially rectilinear.

Even while the calculation of the peak height (or weight) velocity yields information important for the analysis of growth of individuals, it is necessary to recognize additional factors which, in normal children, alter the magnitude of the maximum rate attained. One of the most important is the stage of maturation of an individual compared to others of the same age group. Thus, the value for PHV noted in figure 13 represents the mean regardless of the age at which it occurred. While PHV for these boys occurred at 13.68 years on the average, the range of variability exceeded 4 years.

To illustrate this principle, the boys' and girls' sample from Guatemala is divided into three groups. The first comprises those with an adolescent spurt which was average in terms of its timing; this is defined here as a PHV which occurred within 1 year on either side of the mean for the group, i.e., 12.68–14.68. Those with peaks before 12.68 were placed into an "early" category and those with peaks after 14.68 into a "late" category. The average ages and PHV's of these three subgroups of boys are:

	Sample size	Mean age at PHV	Mean PHV (cm./yr.)
Early . .	19	11.84	10.00
Average . .	74	13.64	9.27
Late . . .	27	15.10	8.73
Total . .	120	13.68	9.26

In other words, the early maturing group displays the most intense PHV and the late maturers the least. For all 120 boys the correlation between the annual increment at PHV and its age of occurrence was -0.29.

The increased height added by early maturers acts as a compensation for the reduced length of their growth period. As a corollary, the reduced magnitude of the spurt of late maturers compensates for the increased length of their growth spurt. Overall, the correlation between the PHV and its age of occurrence tends to reduce the variability in height among adults by balancing the length of the growth period with the magnitude of the spurt.

The same relationships hold for girls. In the Guatemalan study, the analysis of the records of 100 girls yields the following:

	Sample size	Mean age at PHV	Mean PHV (cm./yr.)
Early . . .	15	9.32	8.40
Average . .	57	11.05	8.03
Late . . .	28	12.88	7.80
Total . .	100	11.31	8.03

The correlation between the PHV and its age of occurrence was -0.184.

Despite the lack of a tidy package called "The Growth Spurt" with clearly defined criteria and parameters which are unanimously agreed upon by all auxologists (especially those who work with adolescent growth data), for the purpose of this report the following parameters will be defined operationally. The definitions will be illustrated by reproducing the boys' pseudo-weight velocity curve from figure 8, i.e., the differences of half-year smoothed mean weights, and schematically fitting lines and points, as described below and shown in figure 14.

(1) The first significant deflection upwards from the best fitting straight line (AB) through the incremental data during the relatively stable childhood years identifies the onset of the growth spurt, point B, which begins a new slope (BC) leading to the peak of the growth curve (individual or group).

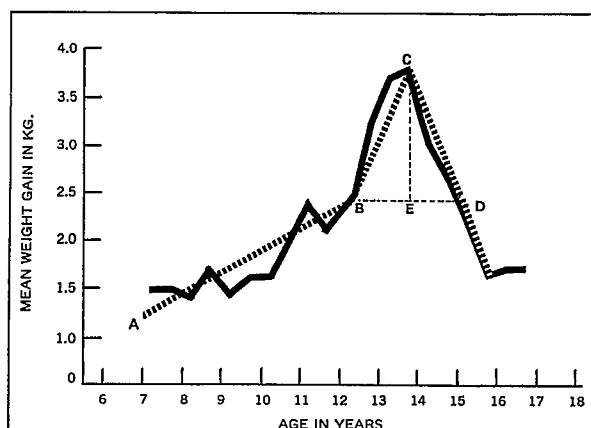

Figure 14. Illustration of the four operationally defined growth spurt parameters (lines schematically applied to figure 8).

(2) The peak of the growth curve (or the peak velocity) is the highest point (C) of the incremental curve, i.e., the point of maximum growth velocity. When considering the magnitude of this peak—i.e. (CE), which is the distance the velocity curve rises above the previous straight line (AB) projected horizontally (BD)—the source of the data must be kept in mind. CE is of quantitative significance only when derived from true, individual growth curves, either in comparing one individual with another or when averaging the individual measures of PHV as on page 15; the use of CE, when derived from population averages as in these HES data, is limited to comparing relative magnitudes, e.g., the boys' peak higher than girls'. CE is an unusual parameter.

(3) The end of the spurt is described by the intersection (D) of the falling incremental curve (CD) and the stable prespurt line (AB) extended horizontally (BD). This arbitrary definition has two advantages: (a) it is easier to apply to group data such as these, and (b) it renders the HES data in a form more comparable to Tanner's in his *Growth at Adolescence.*[11]

(4) The duration of the growth spurt is the chronologic time lapse from onset to the end of the spurt, i.e., the time along the extended horizontal line, BD.

Of these four parameters, the peak velocity is most closely tied to all the other biologic events, both those associated with and those culminating in puberty.[l] In other words, it is the most biologically significant of the four parameters. It is also the most precisely identified. This is true for the peak derived from measurements of individuals (true peak velocity) as well as for the peak of a pseudo-velocity curve derived from the difference between the means in cross-sectional data. In fact, the chronologic timing of the occurrence of peak velocity is the only one of the four parameters above in which the peak of the mean pseudo velocities is also the best estimate of the average of all the individuals. All the other parameters are somewhat distorted when the estimates derive from cross-sectional data because of the difference in individual phasing (as has been stated so frequently in this report). The most artificial of the four parameters is the end of the growth spurt, but the most distorted estimate would be a quantification of the peak (CE), so this is not done in this report.

In addition to timing peak velocity, another one of the best estimates (both describing the population and the individuals within the population) that can be generated from the HES data is the distance (or attained height or weight) curve from quarter-year age groups smoothed by a five-period moving average (figures 2 and 6). When the best estimates of the above four parameters are applied to these graphs, the growth spurt can be quantified so that its magnitude can be better gauged by estimating its proportionate contribution to the total growth of the adult human.

As summarized in the Results section, the boys' mean height spurt started at age 11¾ and ended at 14½ years. When these two points are applied to figure 2, the boys were 147.3 cm. in mean height at the onset of the spurt and 166.7 cm. at the end. They thus gained 19.4 cm. during the 2¾-year spurt. The best estimated mean height[m] when the 17-18 year old boys are fully grown is 177.4 cm. (not 175.5 cm. at age 17½ years as shown in figure 2). Therefore, $\frac{19.4}{177.4}$ or 11 percent of total adult male height was achieved during a growth spurt lasting 2¾ years. In the comparable 2¾-year period immediately prior to the onset of the growth spurt (age 9 to 11¾), the increase in boys' mean height was 14.7 cm. or 8 percent of the adult height. Expressed the other way, it required 3¾ years (8 to 11¾) immediately prior to the adolescent growth spurt to achieve the

[l]The word "puberty" is used in this report as defined in the 1971 compact edition of the *Oxford English Dictionary:* "The state or condition of having become functionally capable of procreating offspring, which is characterized by various symptoms in each sex as by the appearance of hair on the pubes, and on the face in the male."

[m]This method of estimating "fully grown adult height" appears in the Supplemental Discussion, appendix II, B.

same height increase as during the 2¾ years of the spurt.

Similarly, for girls the spurt started at 10¼ years (mean height of 139.6 cm., figure 2) and ended at 12½ (154.8 cm., figure 2). The mean height increase for girls was 15.2 cm. which represents $\frac{15.2}{162.9}$ or 9 percent of total female adult height.[n] In the comparable 2¼-year period (versus 2¾ years for boys) immediately prior to the onset of the growth spurt (age 8 to 10¼), the increase in girls' mean height was 13.1 cm. or 8 percent of their predicted height. Rather than the 2¼ years required during the spurt, it took 3 years during preadolescence to achieve the same increase in height.

The difference in mean adult height between men and women in the United States is 14.5 cm.; 62 percent of this difference is explained by the 1½-year delay in growth-spurt timing between boys and girls. While girls are in their growth spurt (hence are reaching their full growth potential by closure of the epiphysis, or growing ends, of the long bones earlier), boys are continuing to grow at the childhood rate of about 6 cm. per year. During the 1½-year time lag, boys have accumulated almost 9 cm. more height before starting their growth spurt than girls had at the beginning of their spurt. Another 4.2 cm. is accounted for by a slightly more intense spurt (greater height to the boys' peak velocity) and a half-year longer spurt.

This type of analysis can also bring out additional ways in which the two sexes vary in patterns of linear growth and in increases in bulk, or weight, and how the two sexes differ in these two aspects of growth. When the boys' pseudo-weight spurt started at age 12¼, their mean weight was 41.5 kg. (figure 6), and, when it ended at 15 years, their mean weight was 59.3 kg.—a total increment between mean weights of 17.8 kg. in 2¾ years. The predicted adult male mean weight (appendix II), i.e., fully grown before "middle-age obesity," is 77.86 kg.; therefore, $\frac{17.8}{77.86}$ or 23 percent of adult male weight was accumulated in this short 2¾-year spurt. Similarly, the girls' weight spurt began at 10¾ years (36.5 kg., table 14 and figure 6) and ended at 13¼ years (49.9 kg., table 14 and figure 6). The increased average weight was 13.4 kg. in this 2½-year period. The adult female mean weight used in this report is the HES girls' mean weight at 17.5 years (the same age as for height) because of the conceptual and computational problems related to adult female weight discussed in appendix II, B. The mean weight from table 8 for 17-18 year old girls is 57.57 kg.; therefore, 13.4 kg. or 23 percent of total female weight achieved at age 17.5 was accumulated in 2½ years.

Adolescent girls gained 78 percent as much height during their growth spurt as adolescent boys did during theirs, $\frac{15.2 \text{ cm.}}{19.4 \text{ cm.}}$, and girls gained 75 percent as much weight, $\frac{13.4 \text{ kg.}}{17.8 \text{ kg.}}$, even though their growth spurt for weight was a quarter of a year longer than for height, i.e., 2½ years for weight and 2¼ years for height as defined and calculated in this report. Although the percent of adult weight gained during the adolescent spurt by both boys and girls was the same (23 percent), this is sheer coincidence and it is deceptive. The boys' adult base, i.e., the denominator from which the percentage gained was calculated, has been estimated at age 25 while for girls the denominator was at age 17.5 years. This finding can also be seen in the weight-by-height tables 15-26.[o] Not only do boys become taller and heavier but they also become heavier per unit height than do girls. Expressed differently, adolescent boys add more mass, both relative and absolute, than do adolescent girls.

[n]There is much evidence that increase in stature for enough girls has ceased sometime before age 17 so that the population means will no longer show an increase. Therefore, 162.9 cm., the mean height at 17.5 years (17-18 year old group), is used as the adult female height estimate (appendix II).

[o]The quantitative proportionate difference will be estimated in a subsequent report in which this change in body composition and body proportion is examined in detail.

Comparisons With Other Data

Adolescent growth spurt comparisons.—Strictly speaking, no epidemiologically precise comparisons can be made between the HES data and any other population groups because there has never been such an accurately representative sample of a large population as this before: that is, a comparison of obtained values from which can be directly inferred, with confidence, a true difference in the population parameter and not sampling and measurement differences of all kinds. Nevertheless, the best possible comparisons must be made. All data greatly profit by gauging with external comparisons and, with the proper qualifications and adjustments, valid comparisons can be made between different naturally occurring populations even though studied and sampled in somewhat different ways.

The most useful single reference[p] by which all of the adolescent growth spurt parameters estimated in this report can be gauged are estimates stated by Tanner in his *Growth at Adolescence.*[11] The book summarizes so much useful information about growth during adolescence and in a manner so lucid, that it is truly the one standard text in the field. In fact, as stated earlier in this report, one reason for describing the duration and end of growth-spurt parameters was to render the data in a form comparable to Tanner's summary estimates. Unfortunately, the data from which Tanner's estimates are derived are not always clearly defined, some of the estimates are apparently synthesized from not only several sources of data but also from a mixture of longitudinal and cross-sectional study designs, and some are collected over a wider range of years than the HES data. This could have allowed some secular change to occur in the different samples and would have increased the likelihood of drift in measuring technique.

In discussing the adolescent growth spurt on page 1 in *Growth at Adolescence,* Tanner states that "in boys it takes place on the average, from 12½ to 15, and is responsible for a gain in height of about 20 cm. (range 10-30 cm.) accompanied by a gain in weight of about 20 kg. (range 7-30 kg.). The peak velocity of height growth averages about 10 cm. (four inches) per year, which is the rate the boy was growing at age two. The time at which this maximum velocity is reached averages about 14 years, though it may lie anywhere between 12 and 17. In girls the spurt begins about two years earlier than in boys, lasts on the average from 10½ to 13, and is somewhat smaller in magnitude, the peak height velocity averaging about 8 cm. per year."

The mean parameters for boys are remarkably similar but occur one-half to three-quarters of a year earlier: Tanner estimates 12½ to 15, HES estimates 11¾ to 14½. If the HES onset is distorted early by one-quarter year, the adjusted age at onset would be 12 years. This adjustment would give equal durations of 2½ years with HES, but still a half year earlier; however, the estimated HES peak height velocity (the most accurately estimated parameter) remains three-quarters of a year earlier than Tanner's. In addition, adjusting the onset back to 12 years shortens the interval in HES averages from onset to peak from 1½ years to 1¼ years. Therefore, the best conclusion appears to be that the average of the HES boys is closer to being three-quarters of a year earlier than Tanner's boys than it is to being a half year earlier.

Tanner estimates a gain in height during the boys' spurt of about 20 cm., HES estimates 19.4 cm. Tanner estimates a weight gain of about 20 kg., HES estimates 17.8 kg.

For girls, Tanner estimates only the timing of the spurt and the true peak height velocities averaged (but HES data do not include the latter). Tanner's timing estimates for the girls' spurt are about one-quarter year later and one-quarter year longer than the HES estimates, i.e., Tanner, 10½ to 13 years; HES, 10¼ to 12½ years.

[p]These growth-spurt comparisons with Tanner are confined to this single comprehensive text for consistency and ease of reference. However, since publication of this text in 1962, Tanner has extended his analyses and has slightly revised some of his earlier estimates (most notably, the English boys maturing approximately a half year earlier than the estimates given in the earlier text). The reader is referred especially to Tanner's 1966 paper,[5] discussed later on pages 20 to 24 and to "Variations in the Pattern of Pubertal Changes in Boys" by Marshall and Tanner, 1970.[18]

Both Tanner and HES conclude that the girls' peak height velocity is of somewhat smaller magnitude than is the boys'. The most fundamental difference in the two estimates is that Tanner (and most traditional estimates) places the boys' lag in puberty and the growth spurt at about 2 years, whereas the HES data—in just about every parameter of the growth spurt measured—consistently estimates the lag at only 1½ years.

Future HES reports on other maturational assessments and indexes of puberty—skeletal age assessment, age at menarche,[q] the physician's maturational grading by primary and secondary sex characteristics (using Tanner's criteria and technique)—will help clarify the male-female time lag within the HES data. In addition, with these forthcoming variables there can be further comparisons with more of Tanner's data.

There are some other sets of data with which the HES adolescent growth data can also be compared, even though none of these other sets of data have as yet been rendered in as complete and usable a form as have Tanner's data. Preliminary analyses of Johnston's data[16] from the American School in Guatemala (a private school of upper socioeconomic level referred to earlier) have arrived at average chronologic timing of all the individual peak height velocities on about 300 children measured annually from age 5 to 18 years.

For males, the Guatemalan school PHV is about 13.63 years (HES, 13.25 years) while the females' PHV is 11.14 years for girls of European ancestry and 11.36 for girls of Guatemalan ancestry (versus 11.75 years for HES girls). These Guatemalan girls are about a half year earlier in reaching maturity while the Guatemalan boys are more than a third of a year later than are HES boys.

Peak height velocities can be compared with data[r] from the extraordinary longitudinal study of several hundred children conducted by the Child Research Council in Denver, Colorado,[19] which started studying them prenatally and has followed some of these children into their early forties and extended the study to their children. The Denver individual peak height velocities were averaged at 11.84 years for girls (falling between the estimates of HES and Tanner but much further from those of the Guatemalan school) and 13.86 years for boys (falling between Tanner's and the Guatemalan boys but 0.6 year later than HES boys).

In the Denver data, the boys lagged 2.01 years behind the girls while in the Guatemala study a 2.4 year time lag was found. Again, the comparison of other maturational indexes, when available, will help clarify these relationships.

Crossings of male-female distance curves.—Tanner[11] states that the typical girl is "lighter at birth but begins to be heavier at about age 8 and remains so until about 14.5 years." The accurate chronologic timing of the two decussations for both height and weight—one of the most precise estimates available from HES data—places the decussation of mean weight at 8¾ and 13¾ years. This not only shortens by 1½ years the duration by which HES girls are heavier than boys compared to the English children reported on by Tanner in his book, but gives some further credence to the hypothesis that HES boys achieve their adolescent growth spurt one-half to three-quarters of a year earlier than do Tanner's English boys.

Height-weight standards.—Tanner, Whitehouse, and Takaishi[5] published in the *Archives of Diseases of Childhood* in 1966 "Standards from Birth to Maturity for Height, Weight, Height Velocity, and Weight Velocity: British Children, 1965." This is the most up to date and carefully conceived set of "standards"—large population data—to which these HES data can be compared. The article's discussion of the clinical applications to the various problems of assessment of size in the growing child, by itself, makes this an invaluable reference. This is followed by presentation of two sets of standards—one set consisting of height or weight attained at a given age by percentile distribution (*distance* standards) and the other set consisting of rates of growth in height and weight derived from individual growth records (*velocity* standards).

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[q] As a male correlative, an aliquot of boys' serum has been frozen and stored for the future assessment of serum testosterone levels at various ages.

[r] The description of the study and some of the data have been presented in a cross-sectional analysis in a book by McCammon.[19] The data used here are from a later publication by M. M. Maresh.[20]

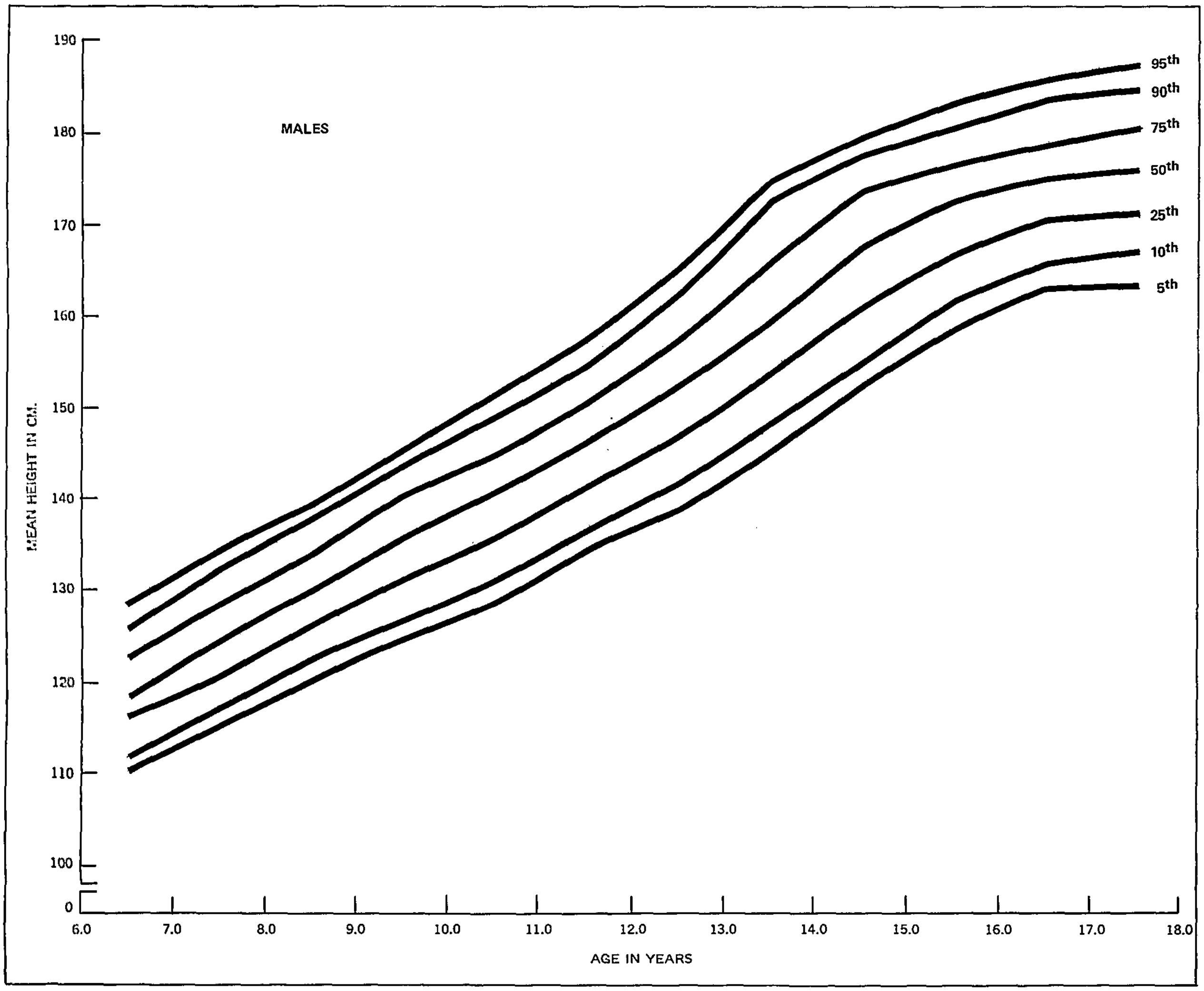

Figure 15. Percentile distribution of U.S. males 6-17 years of age by height in centimeters.

Tanner's development of velocity standards and the analysis of his available longitudinal data remain unique contributions both to those involved in the generic biological implications and problems in human growth and to those seeking clinical standards. As explained throughout this report, the HES data can make only a limited contribution to these areas.

When considering distance standards, however, the story is quite different. While Tanner and a few others have also measured height and weight with great precision on large samples of growing children, none has had available to them such a representative sample as has the HES. The presentation of cross-sectional percentile distributions of height and weight (figures 15-18) which are representative of a vast, well-defined referent population is so unique to the HES data as to be the *raison d'etre* of this report.

As Tanner points out in his introduction, "Children in many countries have been getting larger during the past 50 years or more, both because they are growing up faster and so reaching an adult size at an earlier age, and

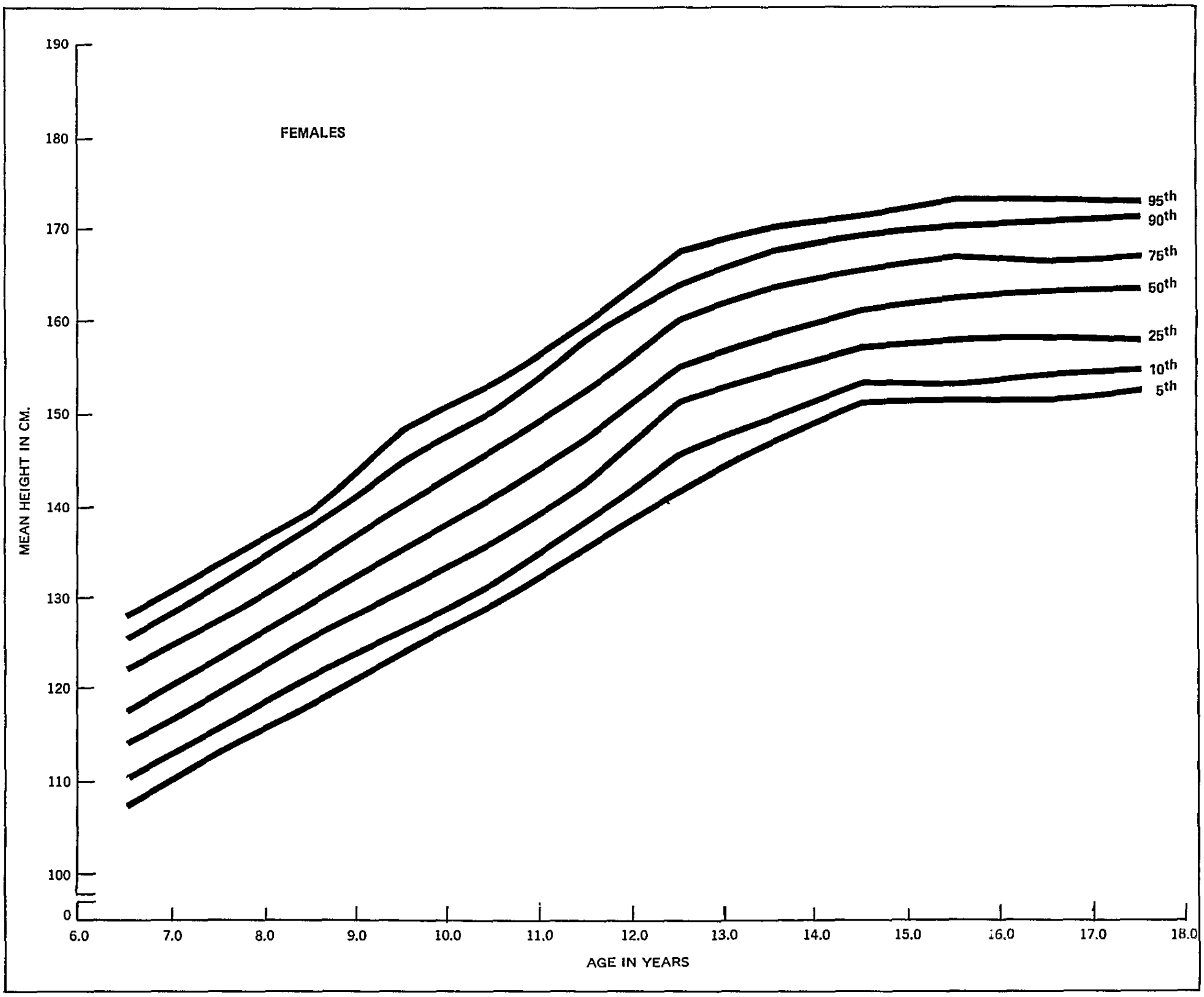

Figure 16. Percentile distribution of U.S. females 6-17 years of age by height in centimeters.

because their adult size itself is increasing [i.e., this refers to the *secular trend* to increasing body size that has been frequently referred to in previous HES reports on body measurements[8, 21, 22]]. Hence, the height-for-age and weight-for-age standards have to be revised every 10 or 15 years until this trend stops." These HES data not only update the most commonly used growth standards in the United States (i.e., the Stuart-Meredith tables based on the Iowa Growth Study data from the 1940's and 1950's[23]) but should completely supplant it for the specified age groups (6-17 years) because of the referent population, i.e., not so much the mere size of the sample but the demonstrably representative quality of it.

The Tanner distance standards are "based mostly on London children measured in 1959 and adjusted slightly so as to be appropriate for 1965."[5] The London children referred to are

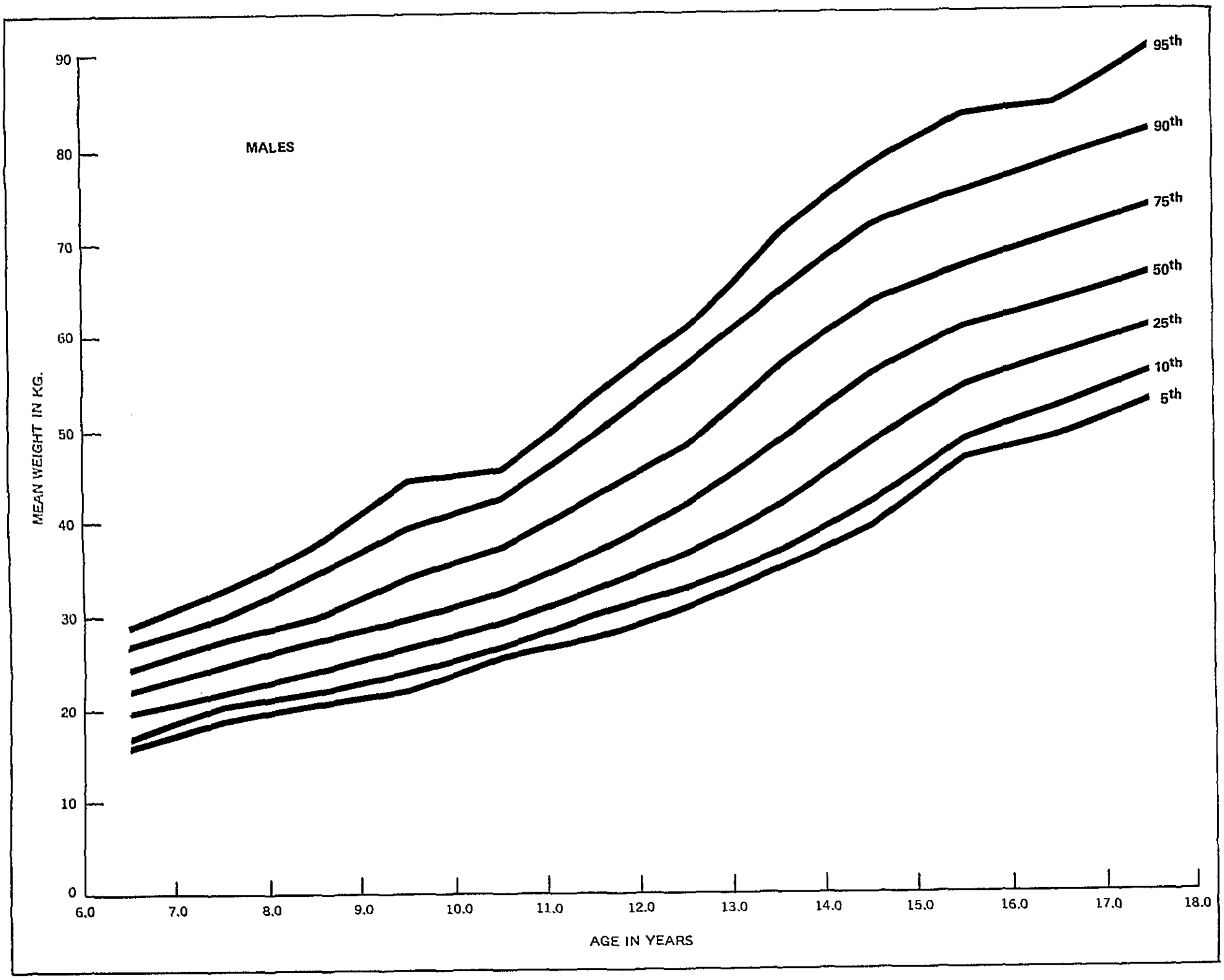

Figure 17. Percentile distribution of U.S. males 6-17 years of age by weight in kilograms.

those measured by Scott, assisted by Tanner's staff, under the auspices of the London County Council (LLC),[24] discussed in previous HES reports.[8, 21, 22] The "adjustment" was a slight increase to account for the secular trend increase and smoothing of the percentile distributions of heights.

The sample deficiencies are several:

(1) The large LCC population was essentially restricted to ages 5½-15½ (the data for older children were derived from the vastly smaller longitudinal growth study at Harpenden).
(2) The sample was limited to London.
(3) The sample was limited to children attending the muncipal schools, whereas the

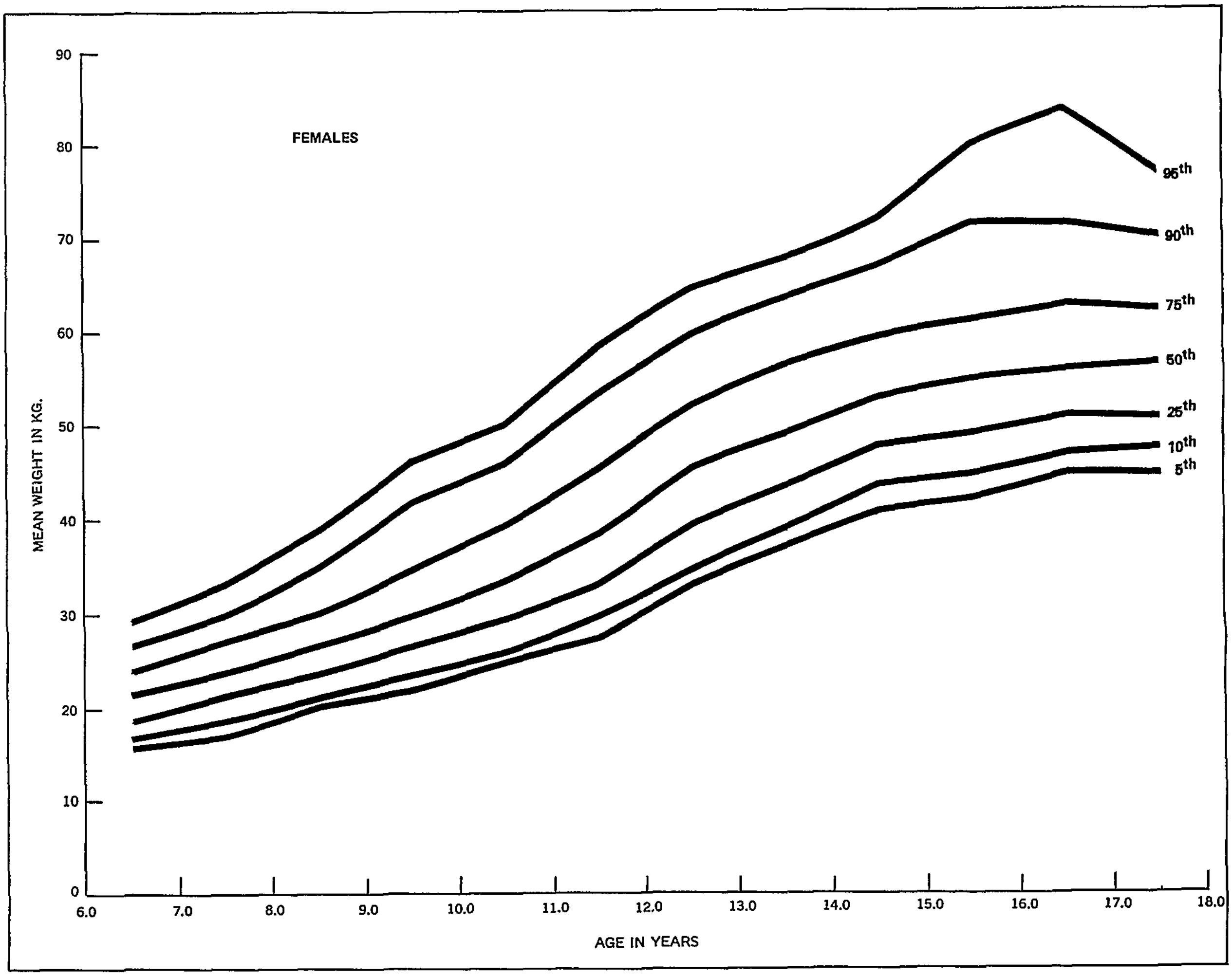

Figure 18. Percentile distribution of U.S. females 6-17 years of age by weight in kilograms.

HES sample effectively represents all noninstitutionalized youths aged 12-17 years in the United States, for 1966-70.

The percentile distributions of values compared in figures 19-22[s] show that the two distributions are remarkably similar and that the United States youths are slightly larger than their British counterparts for both height and weight. This type of comparison validates the ranges of variation in both populations.

[s]The extreme percentiles were noncomparable—3 percent and 97 percent were used in the British distribution. The 25th and the 75th percentiles were deleted for graphic clarity but were not comparatively different from the three percentiles used.

Clinical Applications

The two most clinically useful arrangements of these HES data on heights and weights

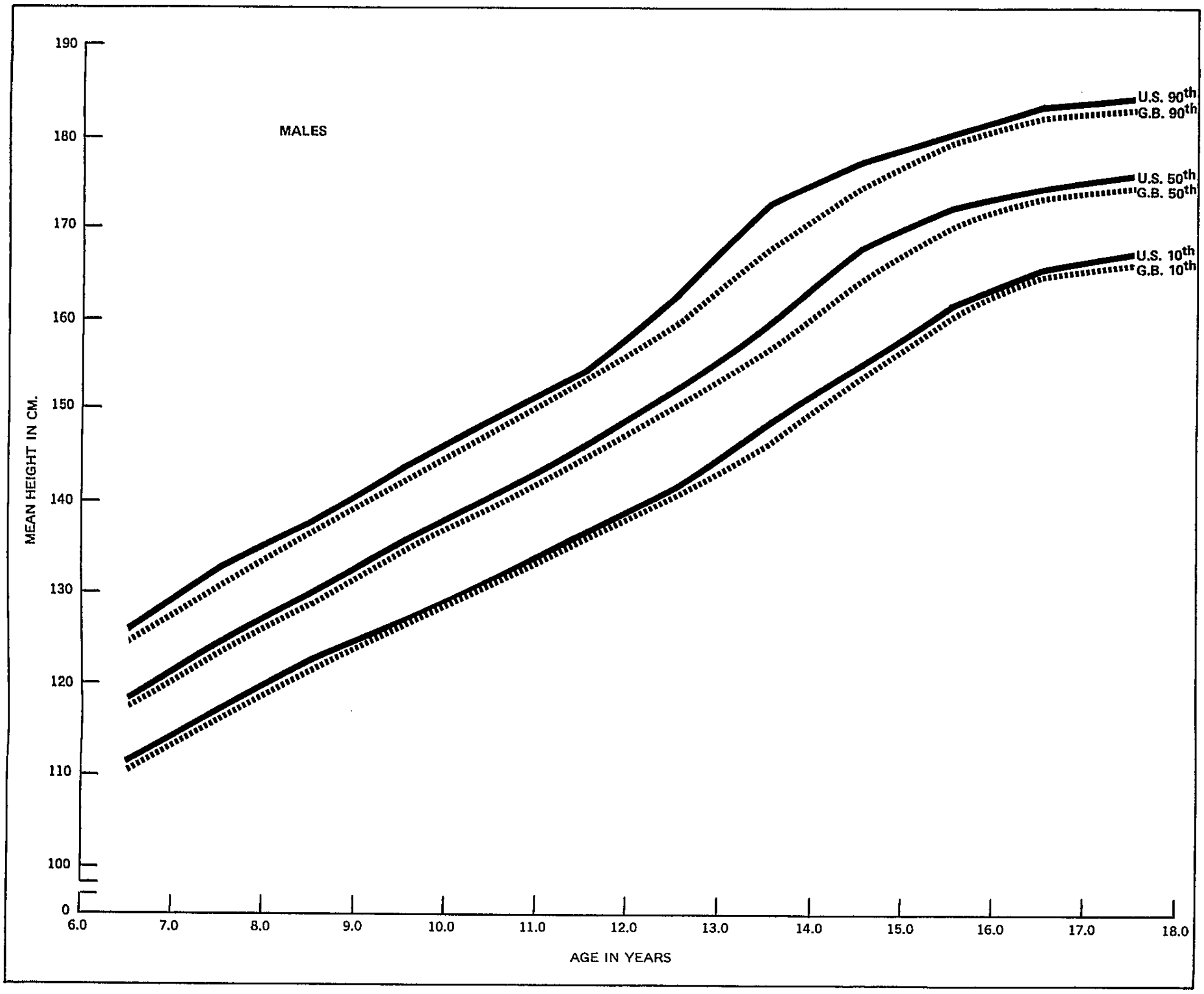

Figure 19. Percentile distribution of U.S. and British males 6-17 years of age by height in centimeters.

are the percentile distributions (distance standards) and the weight-by-height tables. The percentile distributions of height and weight data separately for boys and girls by single year are found in tables 1 and 8 (graphed in figures 15-18), those by half-year intervals are in tables 3 and 10, and those by quarter-year intervals are in tables 5 and 12. The smaller intervals provide slightly more accurate estimates for the individual child. The percentile distributions of weight for designated height categories, separate for boys and for girls, by single-year age intervals from 12-17 are found in tables 15-26 (in kilograms and centimeters and in pounds and inches).

The percentile distributions afford comparison of the height or weight attained at any point in time by an individual youth (or group) with the height or weight of all others in the United States with the same characteristics. Within the limitations of this single report those

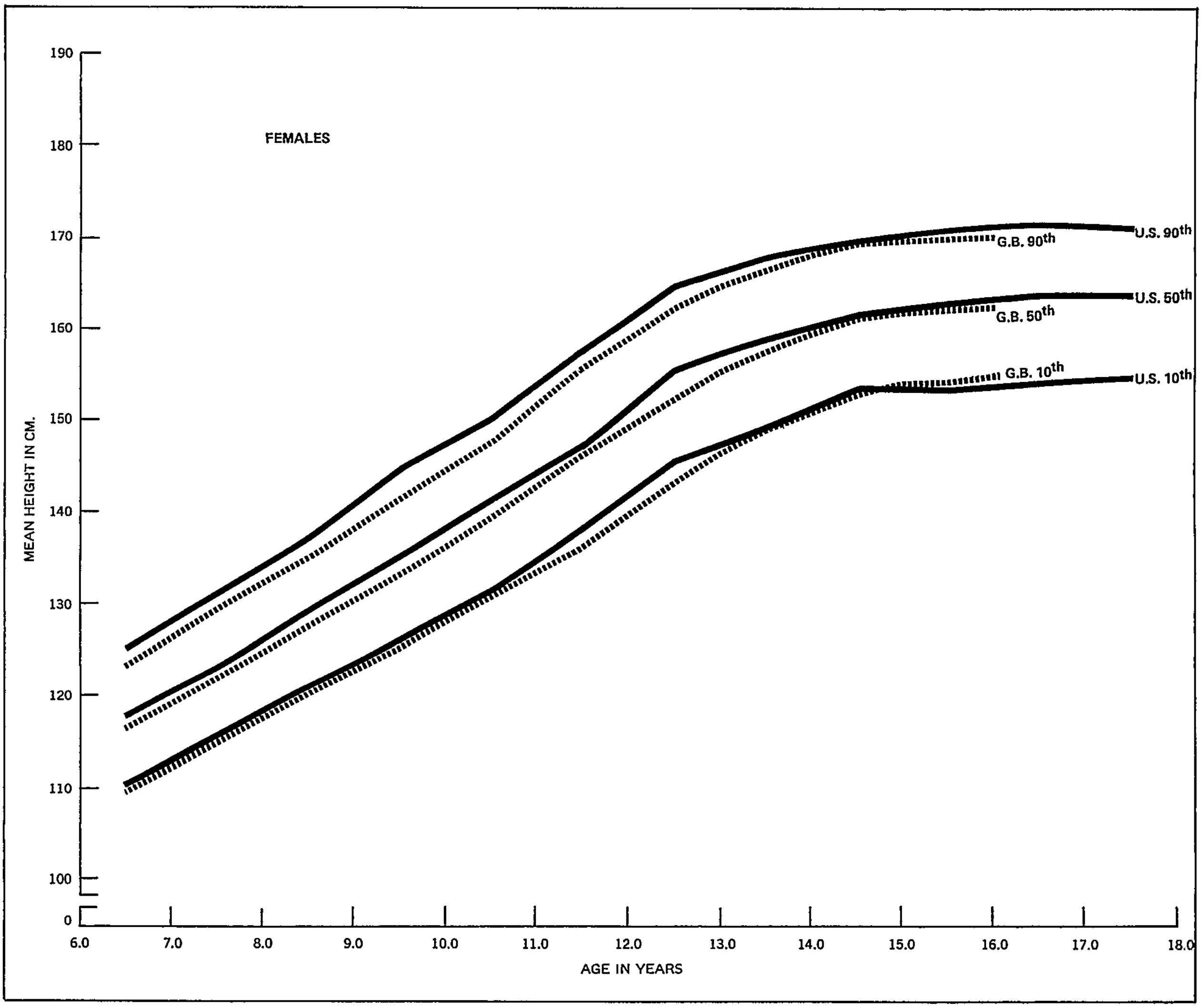

Figure 20. Percentile distribution of U.S. and British females 6-17 years of age by height in centimeters.

characteristics include chronologic age, sex, and height or weight categories. For example, a 14½-year-old boy 177 cm. tall would be at the 90th percentile for height, which means that out of 100 similar boys in the United States in 1966-70, 90 would be shorter and only 10 would be taller. If this same boy weighed 55 kg. (121 lb.), by use of table 19 he would be in the lowest 10 percent for weight of 14-year-old boys of that height; however, if he weighed 84 kg. (184.8 lb.), he would be at the 95th percentile of weight for that height, i.e., of every 100 14-year-old boys in the United States 177 cm. tall, only five would weigh more than he.

Data are in press[25] for skinfold measurements which will allow accurate mapping of an

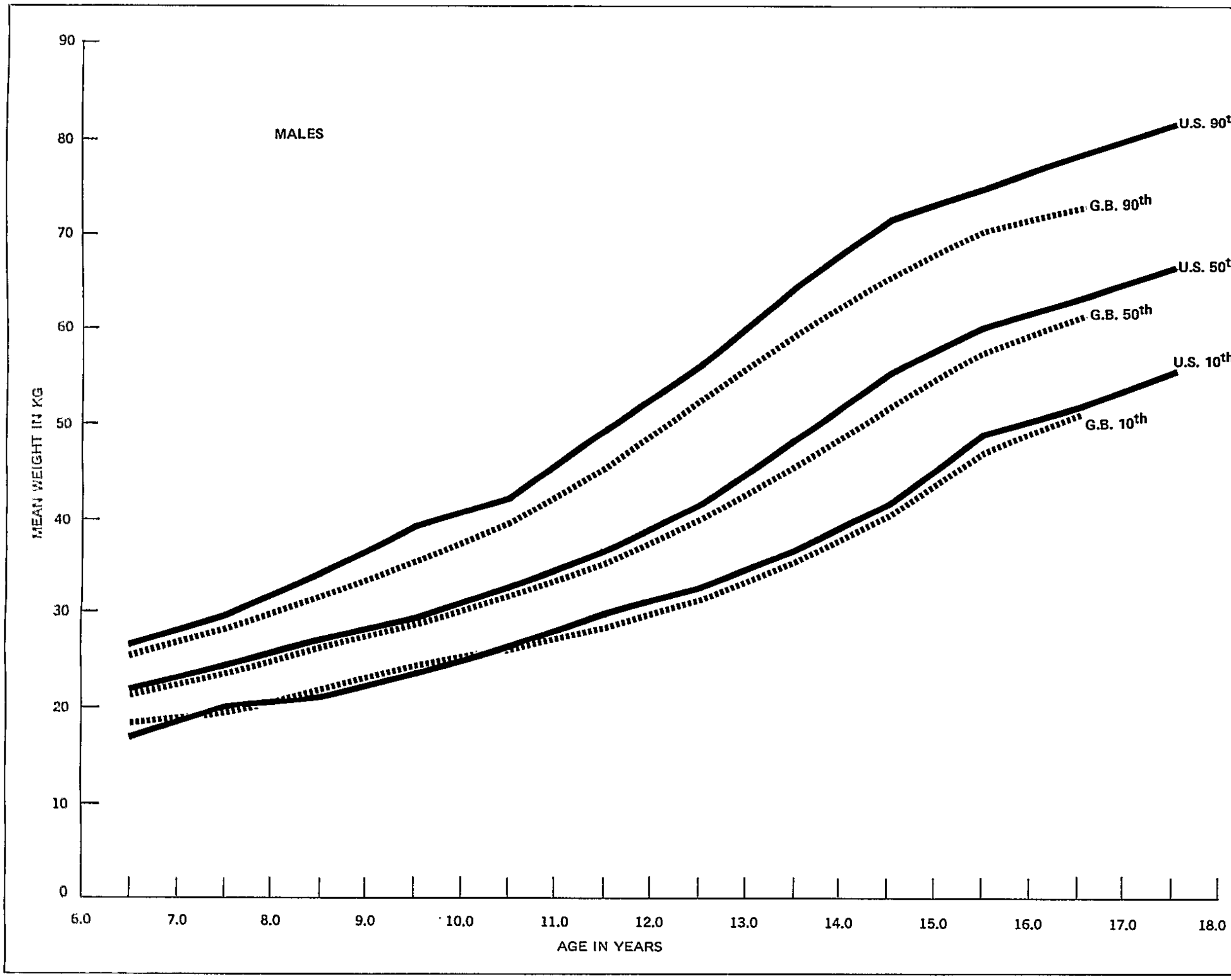

Figure 21. Percentile distribution of U.S. and British males 6-17 years of age by weight in kilograms.

individual by age, sex, race, height, weight, and triceps skinfold thickness. Additional data in analysis cover skeletal maturation, sexual maturation, socioeconomic status, and many other easily identifiable variables which can further map or classify an individual youth.

As already stated, the main clinical function which these data cannot accurately serve is the quantitative mapping of an individual's entire growth curve relative to those of his peers which Tanner's work has achieved so admirably.[5] When enough longitudinal data become available, an accurately quantified series of curves (similar to the crude schematic curve of the two means in figure 13) could be superimposed over the growth spurt in a similar fashion to Tanner's.[5] (In the meantime, Tanner's accurate velocity standards are enthusiastically recommended for clinically assessing the acceleration or deceleration of the rate of growth of an individual. There is no reason to presume that changes in velocity in growth

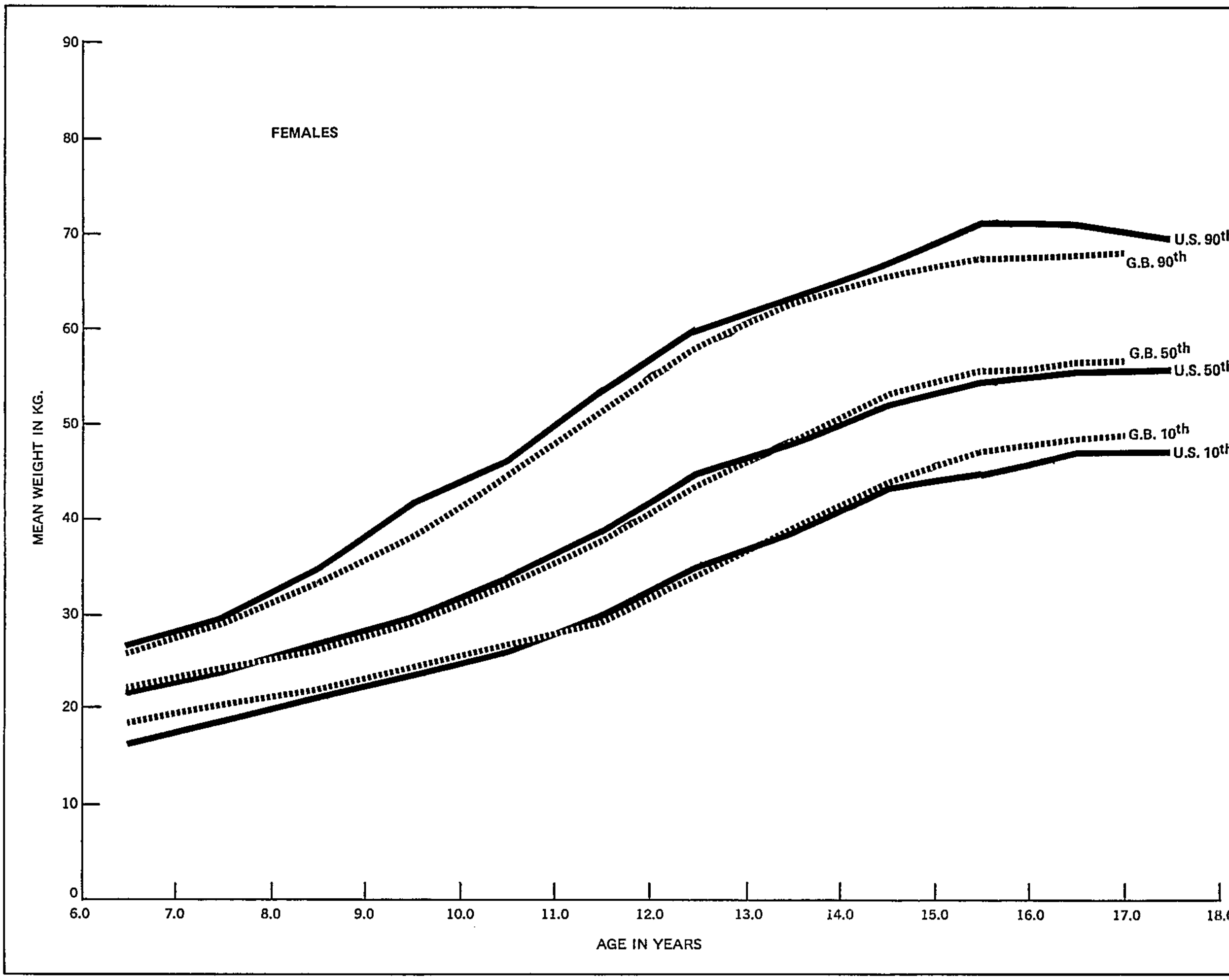

Figure 22. Percentile distribution of U.S. and British females 6-17 years of age by weight in kilograms.

would be any different in British and United States children. Then, only the channel or percentile track which the individual was following would have to be adjusted by 10 or 15 percent.)

Despite this clinical limitation of the HES data, useful qualitative information about the growth pattern of an individual child can be obtained from plotting his serial measurements on the percentile charts as is done in figure 23. These two boys from the American School in Guatemala (upper socioeconomic class, Western European ancestry and culture) were measured each year.

Boy B is relatively short in the younger years, i.e., barely above the 25th percentile. At age 11½ he crosses the 50th percentile and at age 13 he almost reaches the 75th percentile; but by age 17 he falls between the 10th and 25th percentiles. Diagnosis: he is a relatively early maturing boy of smaller than average stature with a "normal pattern of growth."

Boy A is just the opposite. In the younger years he stays at the 75th percentile until many of the other boys are starting their growth spurt after 11 years. He continues to fall relative to the other boys of similar chronologic age until age 14 when he is below the 40th percentile. But he then starts his belated growth spurt and by age 16 more than regains his preadolescent

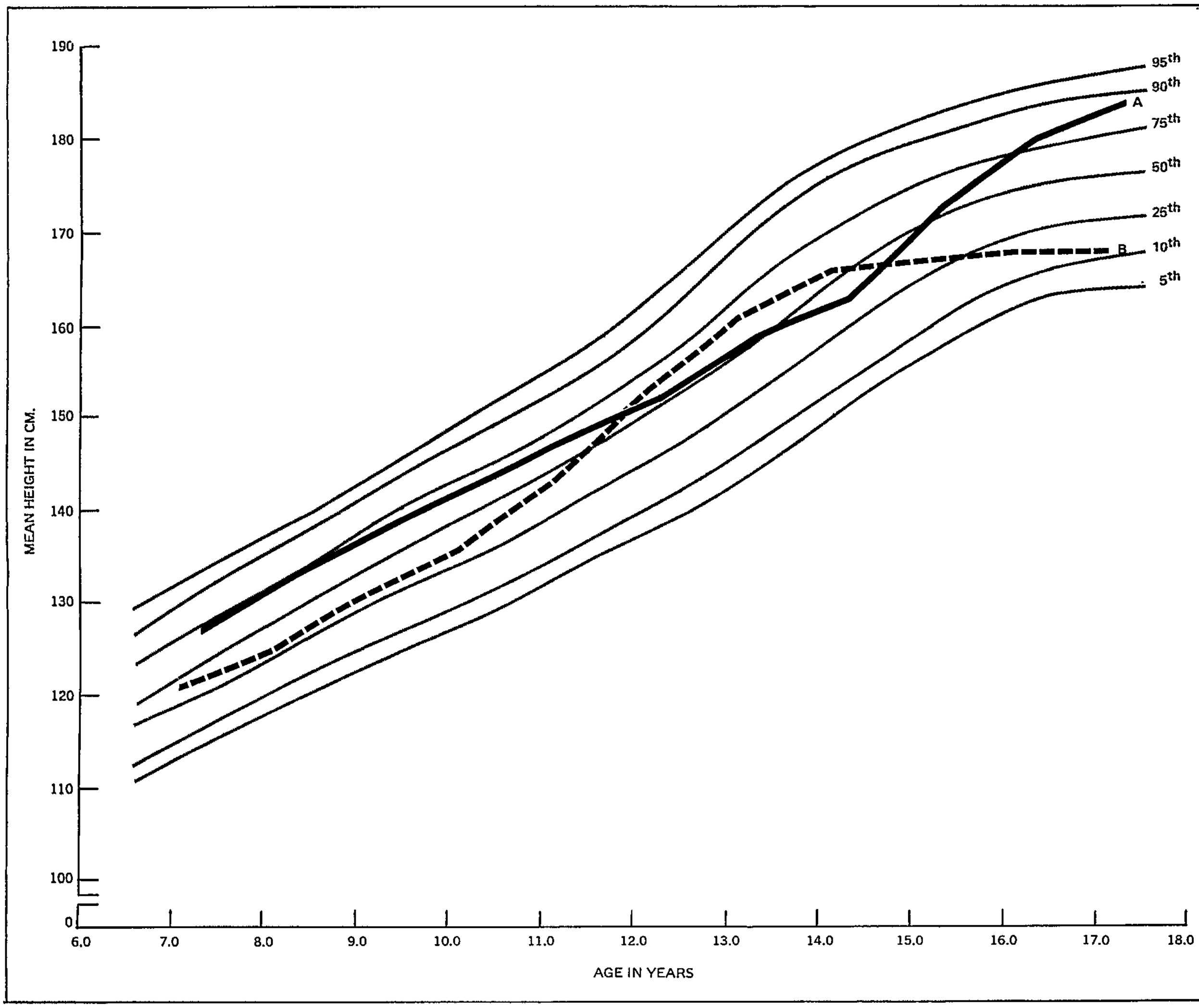

Figure 23. Individual distance curves for two boys from the American School in Guatemala plotted on the percentile distribution for U.S. males (identical to figure 15).

relative position and at age 17 reaches the 90th percentile.

For a general look at an adolescent this information is sufficient, but when either growth intervention therapy is considered or other therapy in which growth rate is a sensitive indicator, use of the more sensitive change in velocity (i.e., Tanner's velocity curves) is indicated.

As has been demonstrated throughout this report, the HES distributions of attained sizes are among the most accurate data that can be generated from the Health Examination Survey and they represent the best population estimates of body size ever obtained. The data are not simply accurate measurements of some 6,768 youths 12-17 years of age, but, in fact, the sample reliably represents 22,692,000 youths. Of equal value to the enormous size of the sample, the population is an extremely well-defined and well-documented one which could be readily identified for years to come.

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LIST OF DETAILED TABLES

Table 1. Height in centimeters of youths aged 12-17 years by sex and age at last birthday: estimated distribution of heights of youths in population, selected percentiles, mean, standard deviation, standard error of the mean, sample size, and average age within age-sex group, United States, 1966-70

Selected variable	Male						Female					
	12 years	13 years	14 years	15 years	16 years	17 years	12 years	13 years	14 years	15 years	16 years	17 years
Height group	Estimated number of youths in population in thousands											
All groups-------	2,032	2,005	1,950	1,899	1,836	1,764	1,970	1,946	1,901	1,850	1,789	1,745
Under 130 cm-----------	14	-	-	-	-	-	-	-	-	-	-	-
130.0-134.9 cm---------	8	5	-	-	-	-	10	3	-	-	-	-
135.0-139.9 cm---------	111	25	7	-	-	-	44	-	2	-	-	-
140.0-144.9 cm---------	241	56	13	-	-	-	116	51	6	5	5	5
145.0-149.9 cm---------	386	204	42	2	1	-	258	165	52	51	33	26
150.0-154.9 cm---------	513	312	135	30	12	3	517	329	196	242	178	151
155.0-159.9 cm---------	432	421	261	99	13	39	525	499	508	400	354	385
160.0-164.9 cm---------	201	393	299	206	108	81	336	515	603	509	547	506
165.0-169.9 cm---------	88	285	432	404	275	248	117	284	372	398	450	433
170.0-174.9 cm---------	21	215	435	574	552	396	42	87	121	188	170	186
175.0-179.9 cm---------	10	68	228	374	511	537	-	10	28	23	45	47
180.0-184.9 cm---------	2	15	81	144	277	297	-	-	7	26	2	2
185.0-189.9 cm---------	-	-	9	48	95	133	-	-	-	3	-	-
190.0-194.9 cm---------	-	-	3	15	10	25	-	-	-	-	-	-
195.0 cm. and over-----	-	-	-	-	7	-	-	-	-	-	-	-
Percentile												
5th--------------------	138.8	145.3	152.1	158.5	162.8	162.8	141.8	146.9	151.3	151.3	151.6	152.3
10th-------------------	141.5	148.2	154.8	161.7	165.5	167.0	145.8	149.5	153.6	153.2	154.1	154.7
25th-------------------	146.8	153.5	160.6	166.8	170.3	170.8	151.1	154.2	157.3	157.4	158.4	158.3
50th-------------------	152.5	159.6	167.8	172.1	174.4	175.8	155.4	158.9	161.2	162.4	163.1	163.2
75th-------------------	157.3	166.0	173.1	176.1	178.8	180.2	160.1	163.5	165.5	167.1	166.6	167.4
90th-------------------	162.6	172.6	177.2	180.4	183.2	184.3	164.1	167.6	169.3	170.6	170.8	171.1
95th-------------------	165.6	174.6	179.7	183.1	185.6	187.3	167.4	170.0	171.3	173.1	173.1	173.0
Mean height in cm------	152.3	159.8	166.7	171.4	174.3	175.5	155.2	158.8	161.4	162.2	162.7	162.9
Standard deviation-----	8.20	9.12	8.69	7.30	6.93	7.00	7.33	6.95	6.17	6.91	6.44	6.37
Standard error of mean------------------	0.43	0.42	0.49	0.32	0.39	0.39	0.30	0.32	0.29	0.48	0.34	0.28
Sample size------------	643	626	618	613	556	489	547	582	586	503	536	469
Average age in years---	12.54	13.49	14.51	15.49	16.47	17.51	12.53	13.48	14.49	15.51	16.49	17.50

Table 2. Height in inches of youths aged 12-17 years by sex and age at last birthday: mean, standard deviation, standard error of the mean, selected percentiles, and coefficient of variation, United States, 1966-70

Sex and age	$\overline{X}$	s	$s_{\overline{X}}$	Percentile							Coefficient of variation
				5th	10th	25th	50th	75th	90th	95th	
Male	In inches										
12 years	60.0	3.23	0.17	54.6	55.7	57.8	60.0	61.9	64.0	65.2	0.054
13 years	62.9	3.59	0.17	57.2	58.3	60.4	62.8	65.4	68.0	68.7	0.057
14 years	65.6	3.42	0.19	59.9	60.9	63.2	66.1	68.1	69.8	70.7	0.052
15 years	67.5	2.87	0.13	62.4	63.7	65.7	67.8	69.3	71.0	72.1	0.043
16 years	68.6	2.73	0.16	64.1	65.2	67.0	68.7	70.4	72.1	73.1	0.040
17 years	69.1	2.76	0.15	64.1	65.7	67.2	69.2	70.9	72.6	73.7	0.040
Female											
12 years	61.1	2.89	0.12	55.8	57.4	59.5	61.2	63.0	64.6	65.9	0.047
13 years	62.5	2.74	0.12	57.8	58.9	60.7	62.6	64.4	66.0	66.9	0.044
14 years	63.5	2.43	0.11	59.6	60.5	61.9	63.5	65.2	66.7	67.4	0.038
15 years	63.9	2.72	0.19	59.6	60.3	62.0	63.9	65.8	67.2	68.1	0.043
16 years	64.0	2.54	0.13	59.7	60.7	62.4	64.2	65.6	67.2	68.1	0.040
17 years	64.1	2.51	0.11	60.0	60.9	62.3	64.3	65.9	67.4	68.1	0.039

NOTE: $\overline{X}$ = mean, s = standard deviation, and $s_{\overline{X}}$ standard error of mean.

Table 3. Height in centimeters of youths aged 12-18 years by sex and half-year age group: average age, sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Sex and age	Average age	n	N	$\bar{X}$	s	$s_{\bar{X}}$	Percentile						
							5th	10th	25th	50th	75th	90th	95th
				In centimeters									
Male													
12 years-----------	12.16	121	392	150.6	8.51	0.92	138.2	138.9	145.3	150.2	156.1	161.6	163.8
12 1/2 years-------	12.51	344	1,061	151.5	7.80	0.63	139.2	141.4	146.3	152.2	156.4	161.1	163.7
13 years-----------	12.98	333	1,075	155.5	8.62	0.47	141.6	145.5	149.9	155.7	161.1	166.6	170.3
13 1/2 years-------	13.49	328	1,040	160.1	8.90	0.64	145.9	148.8	153.6	159.4	165.9	173.2	175.2
14 years-----------	13.99	276	906	163.5	8.64	0.69	149.1	152.0	157.4	163.4	169.9	174.3	177.7
14 1/2 years-------	14.49	323	1,001	166.6	8.76	0.64	152.2	155.0	159.7	167.9	173.2	177.2	179.7
15 years-----------	15.00	317	986	169.5	7.94	0.52	155.9	158.9	163.8	169.8	175.0	179.2	181.8
15 1/2 years-------	15.49	323	992	171.3	7.02	0.39	159.3	161.9	167.0	171.5	175.5	180.3	183.4
16 years-----------	16.02	294	984	173.3	6.81	0.44	161.7	164.2	169.2	173.9	177.8	180.8	183.6
16 1/2 years-------	16.48	252	817	174.7	6.44	0.33	164.3	166.6	171.1	174.8	178.6	182.8	185.2
17 years-----------	16.99	260	894	175.3	7.07	0.50	163.3	166.3	170.1	175.8	179.9	183.9	186.5
17 1/2 years-------	17.49	243	862	175.6	7.10	0.60	162.9	167.1	170.5	175.8	179.8	185.4	188.2
18 years-----------	17.91	131	472	175.6	6.97	0.66	162.5	167.1	171.1	175.5	180.4	185.1	186.6
Female													
12 years-----------	12.15	103	357	153.7	6.69	0.70	142.0	145.8	149.7	153.5	156.7	162.1	167.6
12 1/2 years-------	12.49	294	1,077	155.2	7.57	0.45	141.3	144.9	150.9	155.5	160.5	164.3	166.7
13 years-----------	13.00	313	1,077	157.0	7.08	0.36	144.8	147.8	152.4	157.2	161.7	166.5	169.0
13 1/2 years-------	13.50	289	971	159.1	6.80	0.43	147.4	150.3	154.7	158.9	163.8	168.2	170.1
14 years-----------	14.00	288	949	160.1	6.42	0.44	149.1	151.5	156.2	160.7	164.5	167.8	169.8
14 1/4 years-------	14.49	286	904	161.4	6.26	0.33	150.6	153.6	157.3	161.3	165.3	169.8	171.3
15 years-----------	14.99	262	902	161.9	6.27	0.38	152.1	154.3	157.4	161.8	166.6	169.7	171.8
15 1/2 years-------	15.51	254	960	162.6	7.39	0.61	151.7	153.2	157.3	162.5	167.7	171.5	173.7
16 years-----------	16.00	283	989	162.3	6.43	0.47	151.2	153.6	158.0	162.6	166.7	170.1	171.9
16 1/2 years-------	16.49	237	776	162.5	6.41	0.39	151.6	153.7	158.1	163.1	166.6	170.7	172.7
17 years-----------	17.00	275	986	163.1	6.43	0.44	151.6	155.0	158.8	163.6	166.9	171.6	174.1
17 1/2 years-------	17.50	223	805	162.7	6.15	0.40	151.9	154.7	158.3	162.9	167.1	170.7	172.3
18 years-----------	17.92	116	442	162.8	6.78	0.60	152.5	154.3	157.6	162.4	167.7	171.4	175.2

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 4. Height in inches of youths aged 12-18 years by sex and half-year age group: average age, sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Sex and age	Average age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile 5th	10th	25th	50th	75th	90th	95th
				In inches									
Male													
12 years	12.16	121	392	59.3	3.35	0.36	54.4	54.7	57.2	59.1	61.5	63.6	64.5
12 1/2 years	12.51	344	1,061	59.7	3.07	0.25	54.8	55.7	57.6	59.9	61.6	63.4	64.4
13 years	12.98	333	1,075	61.2	3.39	0.18	55.8	57.3	59.0	61.3	63.4	65.6	67.1
13 1/2 years	13.49	328	1,040	63.0	3.50	0.25	57.4	58.6	60.5	62.8	65.3	68.2	69.0
14 years	13.99	276	906	64.4	3.40	0.27	58.7	59.8	62.0	64.3	66.9	68.6	70.0
14 1/2 years	14.49	323	1,001	65.6	3.45	0.25	59.9	61.0	62.9	66.1	68.2	69.8	70.8
15 years	15.00	317	986	66.7	3.13	0.21	61.4	62.6	64.5	66.8	68.9	70.6	71.6
15 1/2 years	15.49	323	992	67.4	2.76	0.15	62.7	63.7	65.8	67.5	69.1	71.0	72.2
16 years	16.02	294	984	68.2	2.68	0.18	63.7	64.6	66.6	68.5	70.0	71.2	72.3
16 1/2 years	16.48	252	817	68.8	2.54	0.13	64.7	65.6	67.4	68.8	70.3	72.0	72.9
17 years	16.99	260	894	69.0	2.78	0.20	64.3	65.5	67.0	69.2	70.8	72.4	73.4
17 1/2 years	17.49	243	862	69.1	2.80	0.24	64.1	65.8	67.1	69.2	70.8	73.0	74.1
18 years	17.91	131	472	69.1	2.74	0.26	64.0	65.8	67.4	69.1	71.0	72.9	73.5
Female													
12 years	12.15	103	357	60.5	2.63	0.28	55.9	57.4	58.9	60.4	61.7	63.8	66.0
12 1/2 years	12.49	294	1,077	61.1	2.98	0.18	55.6	57.1	59.4	61.2	63.2	64.7	65.6
13 years	13.00	313	1,077	61.8	2.79	0.14	57.0	58.2	60.0	61.9	63.7	65.6	66.5
13 1/2 years	13.50	289	971	62.6	2.68	0.17	58.0	59.2	60.9	62.6	64.5	66.2	67.0
14 years	14.00	288	949	63.0	2.53	0.17	58.7	59.6	61.5	63.3	64.8	66.1	66.8
14 1/2 years	14.49	286	904	63.5	2.46	0.13	59.3	60.5	61.9	63.5	65.1	66.8	67.4
15 years	14.99	262	902	63.8	2.47	0.15	59.9	60.8	62.0	63.7	65.6	66.8	67.6
15 1/2 years	15.51	254	960	64.0	2.91	0.24	59.7	60.3	61.9	64.0	66.0	67.5	68.4
16 years	16.00	283	989	63.9	2.53	0.18	59.5	60.5	62.2	64.0	65.6	67.0	67.7
16 1/2 years	16.49	237	776	64.0	2.52	0.15	59.7	60.5	62.2	64.2	65.6	67.2	68.0
17 years	17.00	275	986	64.2	2.53	0.17	59.7	61.0	62.5	64.4	65.7	67.6	68.5
17 1/2 years	17.50	223	805	64.0	2.42	0.16	59.8	60.9	62.3	64.1	65.8	67.2	67.8
18 years	17.92	116	442	64.1	2.67	0.24	60.0	60.8	62.1	63.9	66.0	67.5	69.0

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 5. Height in centimeters of youths aged 12-18 years by sex and quarter-year age group: average age, sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Sex and age	Average age	n	N	$\bar{X}$	s	$s_{\bar{X}}$	Percentile						
							5th	10th	25th	50th	75th	90th	95th
				In centimeters									
Male													
12 years	12.10	43	144	151.1	8.18	1.44	138.6	141.2	146.1	150.5	153.9	159.9	163.8
12 1/4 years	12.24	150	465	150.2	7.87	0.65	138.3	140.1	144.1	149.5	155.9	161.0	162.7
12 1/2 years	12.50	187	577	151.5	8.33	0.87	138.0	140.4	145.9	152.6	156.8	161.2	165.1
12 3/4 years	12.76	184	589	154.3	7.48	0.62	142.3	146.1	149.6	153.7	158.0	164.4	167.6
13 years	12.99	165	520	154.7	9.37	0.67	136.9	143.0	148.1	155.4	161.4	166.6	170.3
13 1/4 years	13.25	154	511	158.9	8.55	0.82	146.2	148.5	153.0	157.8	164.9	171.1	174.4
13 1/2 years	13.49	162	524	159.7	9.11	1.06	144.7	148.2	153.3	158.8	165.3	173.2	176.1
13 3/4 years	13.75	158	478	161.4	8.44	0.68	148.1	149.9	155.8	161.8	167.5	173.1	174.6
14 years	14.00	135	465	164.0	7.90	0.69	151.4	153.2	157.8	164.2	169.8	173.6	177.0
14 1/4 years	14.26	159	503	165.4	10.01	1.15	148.5	152.5	157.9	165.1	172.7	178.5	182.1
14 1/2 years	14.50	155	487	167.5	7.96	0.79	153.5	156.6	161.5	169.4	173.0	176.5	178.7
14 3/4 years	14.76	151	467	167.1	8.46	0.99	152.7	155.2	162.3	167.7	173.5	176.5	180.8
15 years	15.00	155	489	169.4	7.59	0.59	156.3	158.7	163.7	169.4	174.8	178.1	181.4
15 1/4 years	15.25	169	511	171.4	7.57	0.62	159.2	160.8	166.5	171.7	176.5	180.5	183.1
15 1/2 years	15.50	159	493	171.2	6.89	0.43	159.8	162.8	166.8	171.2	174.7	179.5	185.0
15 3/4 years	15.75	150	461	171.9	7.04	0.70	159.1	163.9	167.6	172.6	176.1	181.0	183.0
16 years	16.01	134	456	172.9	6.13	0.53	161.5	164.5	170.1	173.7	177.0	179.6	181.3
16 1/4 years	16.24	157	541	174.5	7.33	0.82	162.4	163.9	170.4	175.1	178.8	184.0	186.5
16 1/2 years	16.50	135	413	174.3	6.56	0.44	165.1	166.8	170.5	173.9	178.4	182.4	184.5
16 3/4 years	16.75	122	401	174.7	6.78	0.66	164.6	166.1	169.8	174.4	179.6	183.1	185.4
17 years	17.00	136	479	175.1	6.94	0.61	163.2	166.4	170.5	175.6	179.7	183.7	186.3
17 1/4 years	17.26	125	435	176.4	6.97	0.71	162.6	167.5	172.1	176.7	181.3	184.3	188.0
17 1/2 years	17.50	111	396	175.4	7.15	0.89	162.9	165.8	170.3	175.2	180.1	185.4	187.8
17 3/4 years	17.75	113	409	175.1	7.32	0.77	162.7	167.2	170.3	175.3	179.7	184.7	189.3
18 years	17.97	76	275	176.0	6.46	0.63	165.7	167.3	171.3	175.8	180.4	185.3	186.4
Female													
12 years	12.10	42	153	154.5	7.05	1.38	142.2	145.9	150.8	153.8	157.3	167.0	167.9
12 1/4 years	12.27	142	520	153.8	7.20	0.64	141.0	143.6	149.5	153.9	158.5	162.5	165.6
12 1/2 years	12.50	140	511	155.6	7.69	0.60	141.8	145.4	151.7	155.5	160.4	164.6	168.3
12 3/4 years	12.75	147	517	156.0	6.82	0.57	143.6	147.5	151.8	156.3	160.5	164.5	166.6
13 years	13.01	166	578	157.1	7.30	0.43	143.8	148.3	152.5	157.3	162.7	166.7	169.2
13 1/4 years	13.25	144	461	158.1	7.54	0.73	145.3	146.8	152.6	158.6	163.4	167.7	169.5
13 1/2 years	13.50	146	500	159.2	6.08	0.42	149.6	152.1	155.2	158.8	163.3	167.7	170.2
13 3/4 years	13.76	148	499	159.3	6.67	0.56	147.5	149.5	155.2	159.9	164.2	167.5	169.4
14 years	14.01	138	452	159.8	6.59	0.53	149.1	151.5	155.9	160.3	164.1	167.2	170.5
14 1/4 years	14.25	159	510	161.3	6.00	0.62	150.8	153.4	157.6	161.2	164.7	168.4	170.8
14 1/2 years	14.51	137	415	161.2	6.66	0.63	150.3	152.6	157.1	161.2	165.4	170.3	172.2
14 3/4 years	14.76	130	457	162.5	6.43	0.69	153.6	154.7	157.7	162.9	167.2	170.0	174.1
15 years	14.99	133	449	161.3	5.73	0.53	151.7	154.6	157.5	160.7	164.8	169.4	171.4
15 1/4 years	15.25	135	479	162.2	6.68	0.58	151.3	153.2	157.3	163.2	166.7	170.3	171.8
15 1/2 years	15.51	114	433	161.8	7.27	0.92	151.8	153.2	156.4	161.3	167.4	171.1	173.5
15 3/4 years	15.75	136	526	162.9	7.19	0.84	150.8	152.8	158.1	163.3	167.8	170.7	175.1
16 years	16.01	141	474	161.9	6.38	0.71	152.4	153.6	157.5	161.6	166.6	169.8	172.2
16 1/4 years	16.24	138	491	163.6	6.17	0.51	152.7	155.8	160.2	164.8	166.8	170.7	173.6
16 1/2 years	16.50	112	341	161.5	6.51	0.70	151.3	153.0	157.2	161.8	166.1	170.2	172.2
16 3/4 years	16.76	135	450	162.9	6.52	0.52	151.5	154.0	158.6	162.8	167.3	171.7	173.0
17 years	17.00	135	477	163.0	6.48	0.71	151.5	154.5	158.9	163.4	167.0	171.1	173.3
17 1/4 years	17.24	125	461	162.7	6.62	0.52	151.5	153.8	157.8	164.2	166.9	171.3	173.6
17 1/2 years	17.51	111	415	162.9	6.02	0.59	152.7	155.7	158.4	162.6	168.1	171.4	172.8
17 3/4 years	17.75	90	325	162.9	5.90	0.87	152.4	154.4	158.3	163.1	167.4	169.9	171.7
18 years	17.97	79	306	163.0	6.77	0.74	152.5	154.6	158.2	162.5	167.6	171.4	175.3

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 6. Height in centimeters of males and females aged 6-18 years by half-year age group: differences between successive groups, 3-period moving averages of mean heights, and differences between successive moving averages, by sex, United States, 1966-70

Age	Male				Female			
	$\bar{X}$	d^1	3-period moving average	d^2	$\bar{X}$	d^1	3-period moving average	d^2
	In centimeters							
6 years	(1)				(1)			
6 1/2 years	118.3				117.6			
		3.4				3.2		
7 years	121.7		121.5		120.8		120.7	
		2.8		3.2		2.9		2.9
7 1/2 years	124.5		124.7		123.7		123.6	
		3.3		2.7		2.6		2.8
8 years	127.8		127.4		126.3		126.4	
		2.2		2.7		2.8		2.9
8 1/2 years	130.0		130.1		129.1		129.3	
		2.6		2.6		3.4		3.1
9 years	132.6		132.7		132.5		132.4	
		2.8		2.4		3.0		3.1
9 1/2 years	135.4		135.1		135.5		135.5	
		2.0		2.5		3.1		2.7
10 years	137.4		137.6		138.6		138.2	
		2.7		2.6		2.0		2.9
10 1/2 years	140.1		140.2		140.6		141.1	
		2.9		2.9		3.6		3.1
11 years	143.0		143.1		144.2		144.2	
		3.1		2.8		3.5		3.5
11 1/2 years	146.1		145.9		147.7		147.7	
		2.6		2.9		3.4		3.6
12 years	148.7		148.8		151.1		151.3	
		2.8		3.1		4.1		3.1
12 1/2 years	151.5		151.9		155.2		154.4	
		4.0		3.8		1.8		2.7
13 years	155.5		155.7		157.0		157.1	
		4.6		4.0		2.1		1.6
13 1/2 years	160.1		159.7		159.1		158.7	
		3.4		3.7		1.0		1.5
14 years	163.5		163.4		160.1		160.2	
		3.1		3.1		1.3		0.9
14 1/2 years	166.6		166.5		161.4		161.1	
		2.9		2.6		0.5		0.9
15 years	169.5		169.1		161.9		162.0	
		1.8		2.3		0.7		0.3
15 1/2 years	171.3		171.4		162.6		162.3	
		2.0		1.7		-0.3		0.2
16 years	173.3		173.1		162.3		162.5	
		1.4		1.3		0.2		0.1
16 1/2 years	174.7		174.4		162.5		162.6	
		0.6		0.8		0.6		0.2
17 years	175.3		175.2		163.1		162.8	
		0.3				-0.4		
17 1/2 years	175.6				162.7			
18 years	(1)				(1)			

NOTE: $\bar{X}$= mean, d^1 = difference between successive group means, and d^2= difference between successive moving averages.

[1]No value is recorded for this age group since the average age of youths falling in this category was not sufficiently close to the age specified. For further discussion see p. 4.

Table 7. Height in centimeters of males and females aged 6-18 years by quarter-year age group: differences between successive groups, 5-period moving averages of mean heights, and differences between successive moving averages, by sex, United States, 1966-70

Age	Male				Female			
	$\bar{X}$	d^1	5-period moving average	d^2	$\bar{X}$	d^1	5-period moving average	d^2
	In centimeters							
6 years	(1)				(1)			
6 1/4 years	117.4				115.8			
		1.2				1.9		
6 1/2 years	118.6				117.7			
		1.0				1.0		
6 3/4 years	119.6		120.0		118.7		119.1	
		2.3		1.4		2.9		1.7
7 years	121.9		121.4		121.6		120.8	
		0.5		1.6		0.2		1.4
7 1/4 years	122.4		123.0		121.8		122.2	
		2.3		1.6		2.3		1.5
7 1/2 years	124.7		124.6		124.1		123.7	
		1.9		1.4		0.5		1.2
7 3/4 years	126.6		126.0		124.6		124.9	
		0.8		1.5		1.9		1.5
8 years	127.4		127.5		126.5		126.4	
		1.6		1.3		1.1		1.3
8 1/4 years	129.0		128.0		127.6		127.7	
		0.9		1.3		1.7		1.8
8 1/2 years	129.9		130.1		129.3		129.5	
		1.4		1.3		1.2		1.4
8 3/4 years	131.3		131.4		130.5		130.9	
		1.7		1.3		3.0		1.7
9 years	133.0		132.7		133.5		132.6	
		0.9		1.3		0.0		1.4
9 1/4 years	133.9		134.0		133.5		134.0	
		1.5		1.2		2.5		1.6
9 1/2 years	135.4		135.2		136.0		135.6	
		1.0		1.2		0.6		1.2
9 3/4 years	136.4		136.4		136.6		136.8	
		0.9		1.3		1.6		1.5
10 years	137.3		137.7		138.2		138.3	
		1.6		1.2		1.6		1.3
10 1/4 years	138.9		138.9		139.8		139.6	
		1.4		1.3		1.0		1.5
10 1/2 years	140.3		140.2		140.8		141.1	
		1.3		1.4		1.8		1.5
10 3/4 years	141.6		141.6		142.6		142.6	
		1.5		1.4		1.4		1.6
11 years	143.1		143.0		144.0		144.2	
		1.2		1.5		2.0		1.7
11 1/4 years	144.3		144.5		146.0		145.9	
		1.5		1.4		1.7		1.8
11 1/2 years	145.8		145.9		147.7		147.7	
		1.7		1.4		1.3		1.9
11 3/4 years	147.5		147.3		149.0		149.6	
		1.1		1.4		2.7		2.0

NOTE: $\bar{X}$ = mean, d^1 = difference between successive group means, and d^2 = difference between successive moving averages.

[1]No value is recorded for this age group since the average age of youths falling in this category was not sufficiently close to the age specified. For further discussion see p. 4.

Table 7. Height in centimeters of males and females aged 6-18 years by quarter-year age group: differences between successive groups, 5-period moving averages of mean heights, and differences between successive moving averages, by sex, United States, 1966-70—Con.

Age	Male				Female			
	$\overline{X}$	d^1	5-period moving average	d^2	$\overline{X}$	d^1	5-period moving average	d^2
	In centimeters							
12 years	148.6		148.7		151.7		151.6	
		1.6		1.7		2.1		1.6
12 1/4 years	150.2		150.4		153.8		153.2	
		1.3		1.5		1.8		1.6
12 1/2 years	151.5		151.9		155.6		154.8	
		2.8		2.0		0.4		1.3
12 3/4 years	154.3		153.9		156.0		156.1	
		0.4		1.9		1.1		1.1
13 years	154.7		155.8		157.1		157.2	
		4.2		2.0		1.0		0.7
13 1/4 years	158.9		157.8		158.1		157.9	
		0.8		1.9		1.1		0.8
13 1/2 years	159.7		159.7		159.2		158.7	
		1.7		2.2		0.1		0.8
13 3/4 years	161.4		161.9		159.3		159.5	
		2.6		1.7		0.5		0.7
14 years	164.0		163.6		159.8		160.2	
		1.4		1.5		1.5		0.6
14 1/4 years	165.4		165.1		161.3		160.8	
		2.1		1.6		-0.1		0.4
14 1/2 years	167.5		166.7		161.2		161.2	
		-0.4		1.5		1.3		0.5
14 3/4 years	167.1		168.2		162.5		161.7	
		2.3		1.1		-1.2		0.1
15 years	169.4		169.3		161.3		161.8	
		2.0		0.9		0.9		0.3
15 1/4 years	171.4		170.2		162.2		162.1	
		-0.2		1.2		-0.4		-0.1
15 1/2 years	171.2		171.4		161.8		162.0	
		0.7		1.0		1.1		0.5
15 3/4 years	171.9		172.4		162.9		162.5	
		1.0		0.6		-1.0		-0.2
16 years	172.9		173.0		161.9		162.3	
		1.6		0.7		1.7		0.3
16 1/4 years	174.5		173.7		163.6		162.6	
		-0.2		0.6		-2.1		0.0
16 1/2 years	174.3		174.3		161.5		162.6	
		0.4		0.7		1.4		0.1
16 3/4 years	174.7		175.0		162.9		162.7	
		0.4		0.2		0.1		-0.1
17 years	175.1		175.2		163.0		162.6	
		1.3		0.1		-0.3		0.3
17 1/4 years	176.4		175.3		162.7		162.9	
		-1.0				0.2		
17 1/2 years	175.4				162.9			
		-0.3				0.0		
17 3/4 years	175.1				162.9			
18 years	(1)				(1)			

NOTE: $\overline{X}$ = mean, d^1 = difference between successive group means, and d^2 = difference between successive moving averages.

[1]No value is recorded for this age group since the average age of youths falling in this category was not sufficiently close to the age specified. For further discussion see p. 4.

Table 8. Weight in kilograms of youths aged 12-17 years by sex and age at last birthday: estimated distribution of weights of youths in population, selected percentiles, mean, standard deviation, standard error of the mean, sample size, and average age within age-sex group, United States, 1966-70

Selected variable	Male						Female					
	12 years	13 years	14 years	15 years	16 years	17 years	12 years	13 years	14 years	15 years	16 years	17 years
Weight group	Estimated number of youths in population in thousands											
All groups------	2,032	2,005	1,950	1,899	1,836	1,764	1,970	1,946	1,901	1,850	1,789	1,745
Under 25 kg----------	6	-	-	-	-	-	4	-	-	-	-	-
25.00-29.99 kg--------	62	15	5	-	-	-	39	12	-	-	-	-
30.00-34.99 kg--------	290	88	8	-	-	-	156	32	12	5	-	-
35.00-39.99 kg--------	535	309	106	9	5	-	328	253	76	34	4	14
40.00-44.99 kg--------	435	337	195	57	24	2	427	341	176	173	95	92
45.00-49.99 kg--------	299	396	263	184	82	40	372	398	470	333	293	280
50.00-54.99 kg--------	160	274	372	278	184	116	273	336	385	389	443	387
55.00-59.99 kg--------	139	222	346	395	366	243	181	275	347	405	342	408
60.00-64.99 kg--------	48	169	230	350	378	396	100	133	207	192	262	262
65.00-69.99 kg--------	30	79	188	269	326	318	34	82	100	102	145	132
70.00-74.99 kg--------	9	46	80	163	180	244	28	24	72	91	67	67
75.00-79.99 kg--------	11	30	84	57	127	181	11	20	20	36	34	36
80.00-84.99 kg--------	-	7	21	53	68	65	3	25	9	32	38	15
85.00-89.99 kg--------	-	13	12	34	32	46	8	-	5	31	22	16
90.00-99.99 kg--------	2	6	26	26	36	78	-	9	9	6	28	19
100.00-109.99 kg------	-	8	-	12	9	19	-	-	3	14	2	5
110.00-119.99 kg------	-	-	5	3	7	9	-	-	-	2	2	-
120.00-129.99 kg------	-	-	-	2	3	-	-	-	5	-	-	5
130.00 kg. and over---	-	-	2	-	2	-	-	-	-	-	4	-
Percentile												
5th------------------	30.64	34.88	39.19	46.32	48.81	52.55	32.98	36.65	40.40	41.94	44.71	44.55
10th-----------------	32.71	36.82	41.83	48.73	51.80	55.38	34.94	38.84	43.27	44.53	46.64	46.70
25th-----------------	36.54	41.36	48.55	54.07	57.81	60.58	39.51	43.22	47.44	48.93	50.85	50.57
50th-----------------	41.58	48.31	55.32	60.43	63.38	66.20	45.37	48.81	52.54	54.76	55.76	55.89
75th-----------------	47.98	56.48	63.25	67.09	70.15	73.59	52.02	56.53	59.30	60.72	62.18	61.94
90th-----------------	56.23	64.68	71.65	74.99	78.71	81.87	59.58	63.14	66.74	71.26	71.24	69.68
95th-----------------	60.05	70.79	78.08	83.74	84.93	90.91	64.08	67.93	71.48	79.26	83.34	76.18
Mean weight in kg-----	42.98	50.00	56.66	61.61	64.82	68.03	46.59	50.46	54.18	56.47	58.06	57.57
Standard deviation----	9.27	11.74	12.34	11.30	11.47	11.49	9.95	10.30	10.32	11.28	11.51	10.56
Standard error of mean-----------------	0.399	0.458	0.637	0.425	0.555	0.384	0.373	0.483	0.416	0.517	0.676	0.621
Sample size-----------	643	626	618	613	556	489	547	582	586	503	536	469
Average age in years--	12.54	13.49	14.51	15.49	16.47	17.51	12.53	13.48	14.49	15.51	16.49	17.50

Table 9. Weight in pounds of youths aged 12-17 years by sex and age at last birthday: mean, standard deviation, standard error of the mean, selected percentiles, and coefficient of variation, United States, 1966-70

Sex and age	$\bar{X}$	s	$s_{\bar{x}}$	Percentile							Coefficient of variation
				5th	10th	25th	50th	75th	90th	95th	
	In pounds										
Male											
12 years	94.8	20.4	0.88	67.5	72.1	80.6	91.7	105.8	124.0	132.4	0.216
13 years	110.2	25.9	1.01	76.9	81.2	91.2	106.5	124.5	142.6	156.1	0.235
14 years	124.9	27.2	1.40	86.4	92.2	107.0	122.0	139.4	158.0	172.1	0.218
15 years	135.8	24.9	0.94	102.1	107.4	119.2	133.2	147.9	165.3	184.6	0.183
16 years	142.9	25.3	1.22	107.6	114.2	127.4	139.7	154.7	173.5	187.2	0.177
17 years	150.0	25.3	0.85	115.9	122.1	133.6	145.9	162.2	180.5	200.4	0.169
Female											
12 years	102.7	21.9	0.82	72.7	77.0	87.1	100.0	114.7	131.4	141.3	0.214
13 years	111.2	22.7	1.06	80.8	85.6	95.3	107.6	124.6	139.2	149.8	0.204
14 years	119.4	22.7	0.92	89.1	95.4	104.6	115.8	130.7	147.1	157.6	0.191
15 years	124.5	24.9	1.14	92.5	98.2	107.9	120.7	133.9	157.1	174.7	0.200
16 years	128.0	25.4	1.49	98.6	102.8	112.1	122.9	137.1	157.1	183.7	0.198
17 years	126.9	23.3	1.37	98.2	103.0	114.5	123.2	136.6	153.6	167.9	0.183

NOTE: $\bar{X}$ = mean, s = standard deviation, and $s_{\bar{x}}$ standard error of mean.

Table 10. Weight in kilograms of youths aged 12-18 years by sex and half-year age group: average age, sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Sex and age	Average age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
							5th	10th	25th	50th	75th	90th	95th
				In kilograms									
Male													
12 years	12.16	121	392	41.56	9.564	0.932	28.51	30.58	35.63	39.51	45.92	54.83	59.56
12 1/2 years	12.51	344	1,061	42.39	9.022	0.574	31.20	32.79	36.03	40.65	46.94	55.28	58.86
13 years	12.99	333	1,075	45.51	9.748	0.568	31.38	34.37	38.81	44.37	50.80	59.25	62.36
13 1/2 years	13.49	328	1,040	50.39	11.569	0.826	36.10	37.16	41.34	48.53	56.84	66.73	70.59
14 years	13.99	276	906	53.57	12.317	0.761	38.11	40.18	45.11	51.43	59.63	68.68	76.92
14 1/2 years	14.49	323	1,001	56.91	12.665	0.767	38.90	41.25	49.37	55.59	62.57	71.24	79.19
15 years	15.00	317	986	59.35	11.221	0.812	42.90	46.17	51.06	58.33	66.43	74.01	76.54
15 1/2 years	15.49	323	992	61.46	10.922	0.757	46.86	49.38	54.60	59.63	66.54	76.19	83.89
16 years	16.02	294	984	63.58	12.321	0.999	46.75	50.30	56.37	62.03	68.61	77.17	86.03
16 1/2 years	16.48	252	817	64.33	10.093	0.617	50.21	52.60	57.24	62.83	69.90	78.21	81.74
17 years	16.99	260	894	66.48	11.670	0.561	50.14	52.97	59.32	64.79	72.84	80.55	85.78
17 1/2 years	17.49	243	862	68.74	11.448	1.009	52.84	56.45	61.25	66.80	74.30	85.49	90.93
18 years	17.91	131	472	68.73	11.688	0.747	54.01	56.01	60.35	67.22	73.82	79.98	96.17
Female													
12 years	12.15	103	357	45.19	9.411	1.036	32.73	34.33	38.28	43.83	49.84	58.69	62.57
12 1/2 years	12.49	294	1,077	46.41	9.919	0.676	31.82	34.78	39.14	45.46	52.53	59.41	63.65
13 years	13.00	313	1,077	48.64	10.251	0.603	34.91	37.18	41.64	47.14	53.50	62.36	67.47
13 1/2 years	13.50	289	971	50.86	10.729	0.752	36.35	38.65	43.83	49.63	56.44	62.97	72.51
14 years	14.00	288	949	52.16	9.635	0.533	38.29	40.22	46.15	51.04	57.45	63.81	68.11
14 1/2 years	14.49	286	904	54.40	11.338	0.444	41.03	43.19	47.00	52.35	59.86	68.20	72.05
15 years	14.99	262	902	54.85	9.450	0.767	41.38	44.13	48.07	54.01	59.82	65.92	71.25
15 1/2 years	15.51	254	960	56.84	12.025	0.832	41.05	44.22	48.99	55.27	60.81	72.42	82.46
16 years	16.00	283	989	56.74	9.787	0.421	44.46	46.45	50.77	54.86	60.62	68.98	77.75
16 1/2 years	16.49	237	776	58.26	12.024	1.156	45.42	46.66	50.51	55.25	62.83	71.67	83.62
17 years	17.00	275	986	58.29	11.867	0.703	44.42	47.04	50.21	56.79	62.04	72.61	79.14
17 1/2 years	17.50	223	805	57.86	10.307	0.760	44.73	46.92	50.88	55.59	63.25	69.82	82.00
18 years	17.92	116	442	57.56	10.557	1.046	44.43	46.34	50.67	55.71	61.75	71.24	75.28

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. Weight in pounds of youths aged 12-18 years by sex and half-year age group: average age, sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Sex and age	Average age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
							5th	10th	25th	50th	75th	90th	95th
				In pounds									
Male													
12 years----------	12.16	121	392	91.6	21.1	2.06	62.9	67.4	78.6	87.1	101.2	120.9	131.3
12 1/2 years-------	12.51	344	1,061	93.5	19.9	1.27	68.8	72.3	79.4	89.6	103.5	121.9	129.8
13 years----------	12.98	333	1,075	100.3	21.5	1.25	69.2	75.8	85.6	97.8	112.0	130.6	137.5
13 1/2 years-------	13.49	328	1,040	111.1	25.5	1.82	79.6	81.9	91.1	107.0	125.3	147.1	155.6
14 years----------	13.99	276	906	118.1	27.2	1.68	84.0	88.6	99.5	113.4	131.5	151.4	169.6
14 1/2 years-------	14.49	323	1,001	125.5	27.9	1.69	85.8	90.9	108.8	122.6	137.9	157.1	174.6
15 years----------	15.00	317	986	130.9	24.7	1.79	94.6	101.8	112.6	128.6	146.5	163.2	168.7
15 1/2 years-------	15.49	323	992	135.5	24.1	1.67	103.3	108.9	120.4	131.5	146.7	168.0	184.9
16 years----------	16.02	294	984	140.2	27.2	2.20	103.1	110.9	124.2	136.8	151.3	170.1	189.7
16 1/2 years-------	16.48	252	817	141.8	22.2	1.36	110.7	116.0	126.2	138.5	154.1	172.4	180.2
17 years----------	16.99	260	894	146.6	25.7	1.24	110.5	116.8	130.8	142.8	160.6	177.5	189.1
17 1/2 years-------	17.49	243	862	151.5	25.2	2.22	116.5	124.5	135.0	147.3	163.8	188.5	200.5
18 years----------	17.91	131	472	151.5	25.8	1.65	119.1	123.5	133.0	148.2	162.7	176.3	212.0
Female													
12 years----------	12.15	103	357	99.6	20.7	2.28	72.2	75.7	84.4	96.6	109.9	129.4	137.9
12 1/2 years-------	12.49	294	1,077	102.3	21.9	1.49	70.2	76.7	86.3	100.2	115.8	131.0	140.3
13 years----------	13.00	313	1,077	107.2	22.6	1.33	77.0	82.0	91.8	103.9	117.9	137.5	148.7
13 1/2 years-------	13.50	289	971	112.1	23.7	1.66	80.1	85.2	96.6	109.4	124.4	138.8	159.9
14 years----------	14.00	288	949	115.0	21.3	1.17	84.4	88.7	101.7	112.5	126.7	140.7	150.2
14 1/2 years-------	14.49	286	904	119.9	25.0	0.98	90.5	95.2	103.6	115.4	132.0	150.4	158.8
15 years----------	14.99	262	902	120.9	20.8	1.69	91.2	97.3	106.0	119.1	131.9	145.3	157.1
15 1/2 years-------	15.51	254	960	125.3	26.5	1.83	90.5	97.5	108.0	121.8	134.1	159.7	181.8
16 years----------	16.00	283	989	125.1	21.6	0.93	98.0	102.4	111.9	120.9	133.6	152.1	170.3
16 1/2 years-------	16.49	237	776	128.4	26.5	2.55	100.1	102.9	111.4	121.8	138.5	158.0	184.4
17 years----------	17.00	275	986	128.5	26.2	1.55	97.9	103.7	110.7	125.2	136.8	160.1	174.5
17 1/2 years-------	17.50	223	805	127.6	22.7	1.68	98.6	103.4	112.2	122.6	139.4	153.9	180.8
18 years----------	17.92	116	442	126.9	23.3	2.31	98.0	102.2	111.7	122.8	136.1	157.1	166.0

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 12. Weight in kilograms of youths aged 12-18 years by quarter-year age group: average age, sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Sex and age	Average age	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile 5th	10th	25th	50th	75th	90th	95th
Male				In kilograms									
12 years	12.10	43	144	40.83	7.997	1.392	30.8	31.8	35.8	38.6	45.2	51.2	59.1
12 1/4 years	12.24	150	465	41.89	10.192	0.960	29.0	30.9	35.1	39.4	46.3	56.2	62.1
12 1/2 years	12.50	187	577	42.11	8.660	0.816	31.1	32.5	36.0	41.2	46.8	52.0	58.4
12 3/4 years	12.76	184	589	44.74	9.509	0.766	31.6	34.7	38.2	42.5	50.0	57.2	62.9
13 years	12.99	165	520	44.68	9.637	0.715	30.7	33.2	37.2	44.2	50.4	57.7	61.7
13 1/4 years	13.25	154	511	48.44	10.865	0.960	35.2	36.4	39.7	46.5	54.9	64.1	68.9
13 1/2 years	13.49	162	524	49.74	10.961	1.204	35.6	37.1	41.1	48.5	56.6	62.6	67.7
13 3/4 years	13.75	158	478	52.62	12.411	1.027	37.0	39.7	44.2	49.9	58.4	67.0	75.3
14 years	14.00	135	465	53.74	12.108	0.802	38.5	40.3	45.0	51.5	59.8	70.5	76.4
14 1/4 years	14.26	159	503	55.65	13.809	1.366	38.1	40.4	45.8	53.7	63.3	71.5	78.7
14 1/2 years	14.50	155	487	57.36	11.052	0.876	38.9	45.1	51.1	55.7	61.8	70.8	79.3
14 3/4 years	14.76	151	467	57.22	12.907	1.318	39.8	42.3	50.1	56.1	62.6	73.4	77.8
15 years	15.00	155	489	59.18	10.116	0.946	42.9	46.4	51.2	58.6	67.2	73.3	75.4
15 1/4 years	15.25	169	511	61.55	11.188	0.803	46.2	48.3	53.9	61.3	67.1	73.9	83.5
15 1/2 years	15.50	159	493	60.33	10.434	0.667	46.6	48.8	53.7	58.2	65.5	72.9	84.0
15 3/4 years	15.75	150	461	63.06	12.327	0.909	47.8	50.1	56.0	60.5	67.4	80.8	86.6
16 years	16.01	134	456	63.53	11.391	1.378	46.3	49.9	58.0	62.2	68.8	74.8	83.5
16 1/4 years	16.24	157	541	64.22	11.540	0.909	48.1	51.4	57.7	62.7	69.4	77.5	84.5
16 1/2 years	16.50	135	413	64.16	11.493	0.853	50.2	52.1	56.7	62.1	69.7	78.3	81.3
16 3/4 years	16.75	122	401	65.41	9.207	1.020	51.1	52.6	58.3	65.1	70.7	77.6	82.9
17 years	17.00	136	479	66.11	12.556	0.792	50.1	53.1	58.3	64.2	70.7	80.9	89.0
17 1/4 years	17.26	125	435	69.02	11.970	1.249	52.0	57.5	61.3	65.6	76.0	82.8	93.2
17 1/2 years	17.50	111	396	67.40	11.324	1.372	52.5	54.5	60.5	66.6	71.5	80.6	90.3
17 3/4 years	17.75	113	409	69.83	11.505	1.140	55.2	57.4	61.4	68.4	75.4	87.4	91.3
18 years	17.97	76	275	68.39	11.590	1.157	54.0	55.8	59.8	67.5	72.8	79.6	99.0
Female													
12 years	12.10	42	153	45.11	10.324	1.958	33.2	34.1	37.3	44.1	49.5	58.8	70.0
12 1/4 years	12.27	142	520	45.40	9.354	0.655	32.0	34.3	38.9	44.4	51.0	58.6	62.2
12 1/2 years	12.50	140	511	45.66	9.429	0.706	31.8	35.1	38.9	44.5	50.7	58.8	64.1
12 3/4 years	12.75	147	517	48.59	10.538	0.843	34.3	36.2	40.8	48.4	53.5	60.8	69.2
13 years	13.01	166	578	48.13	9.586	0.801	35.6	38.2	42.0	45.6	53.4	61.7	66.5
13 1/4 years	13.25	144	461	50.17	11.295	0.806	35.1	37.5	42.2	47.9	56.7	64.4	71.3
13 1/2 years	13.50	146	500	50.60	10.807	0.890	36.3	38.1	43.7	48.8	56.4	63.0	68.4
13 3/4 years	13.76	148	499	51.82	9.657	1.031	38.3	39.9	44.7	50.7	56.8	63.4	74.2
14 years	14.01	138	452	52.15	10.441	0.781	38.1	40.1	45.1	50.6	58.2	66.0	71.3
14 1/4 years	14.25	159	510	52.73	9.309	0.780	39.5	42.6	47.2	51.0	56.9	64.9	70.3
14 1/2 years	14.51	137	415	55.41	12.641	0.536	41.3	43.7	46.8	53.8	60.7	69.3	72.5
14 3/4 years	14.76	130	457	54.69	8.971	0.775	42.3	45.2	48.6	53.7	59.4	64.9	68.8
15 years	14.99	133	449	54.56	8.877	0.998	42.0	44.1	48.0	53.4	59.7	65.8	71.4
15 1/4 years	15.25	135	479	55.24	11.274	1.178	40.7	42.4	46.5	53.9	61.0	69.6	77.4
15 1/2 years	15.51	114	433	57.56	13.264	1.629	43.5	45.4	49.5	53.8	60.2	76.7	85.2
15 3/4 years	15.75	136	526	57.44	10.708	0.693	41.7	44.5	50.5	56.5	61.2	71.3	75.4
16 years	16.01	141	474	56.43	8.585	0.729	45.8	47.9	51.3	54.6	59.5	67.1	74.3
16 1/4 years	16.24	138	491	57.72	11.630	1.122	44.5	46.1	50.5	53.8	62.0	72.6	84.2
16 1/2 years	16.50	112	341	57.09	9.380	1.218	46.1	47.4	50.4	55.0	61.8	69.8	77.5
16 3/4 years	16.76	135	450	60.40	13.455	1.143	44.6	47.8	51.6	58.5	66.1	75.6	85.1
17 years	17.00	135	477	58.03	12.001	1.092	44.9	47.1	49.4	56.4	62.3	72.1	74.9
17 1/4 years	17.24	125	461	56.64	11.417	1.110	42.0	44.7	49.0	55.6	60.7	67.2	76.9
17 1/2 years	17.51	111	415	58.48	8.956	1.000	47.5	48.7	51.6	56.4	64.2	69.7	76.7
17 3/4 years	17.75	90	325	57.76	11.244	1.207	44.8	46.6	50.8	55.5	62.0	69.4	86.5
18 years	17.97	79	306	57.32	9.764	1.389	44.2	45.8	50.6	55.8	61.8	71.6	73.3

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 13. Weight in kilograms of males and females aged 6-18 years by half-year age group: differences between successive groups, 3-period moving averages of mean weights, and differences between successive moving averages, by sex, United States, 1966-70

Age	Male $\overline{X}$	Male d^1	Male 3-period moving average	Male d^2	Female $\overline{X}$	Female d^1	Female 3-period moving average	Female d^2
	In kilograms							
6 years	(1)				(1)			
6 1/2 years	21.8				21.5			
		1.6				1.3		
7 years	23.4		23.3		22.8		22.9	
		1.2		1.5		1.6		1.3
7 1/2 years	24.6		24.8		24.4		24.2	
		1.7		1.5		1.0		1.5
8 years	26.3		26.3		25.4		25.7	
		1.6		1.4		2.0		1.7
8 1/2 years	27.9		27.7		27.4		27.4	
		1.1		1.7		2.0		2.0
9 years	29.0		29.4		29.4		29.4	
		2.2		1.4		2.1		2.1
9 1/2 years	31.2		30.8		31.5		31.5	
		1.1		1.6		2.0		1.8
10 years	32.3		32.4		33.5		33.3	
		1.3		1.6		1.5		2.1
10 1/2 years	33.6		34.0		35.0		35.4	
		2.5		2.0		2.7		2.1
11 years	36.1		36.0		37.7		37.5	
		2.1		2.4		2.1		2.6
11 1/2 years	38.2		38.4		39.8		40.1	
		2.6		2.1		3.1		2.9
12 years	40.8		40.5		42.9		43.0	
		1.6		2.4		3.5		3.0
12 1/2 years	42.4		42.9		46.4		46.0	
		3.1		3.2		2.2		2.6
13 years	45.5		46.1		48.6		48.6	
		4.9		3.7		2.3		2.0
13 1/2 years	50.4		49.8		50.9		50.6	
		3.2		3.8		1.3		1.9
14 years	53.6		53.6		52.2		52.5	
		3.3		3.0		2.2		1.3
14 1/2 years	56.9		56.6		54.4		53.8	
		2.5		2.7		0.5		1.6
15 years	59.4		59.3		54.9		55.4	
		2.1		2.2		1.9		0.7
15 1/2 years	61.5		61.5		56.8		56.1	
		2.1		1.6		-0.1		1.2
16 years	63.6		63.1		56.7		57.3	
		0.7		1.7		1.6		0.5
16 1/2 years	64.3		64.8		58.3		57.8	
		2.2		1.7		0		0.4
17 years	66.5		66.5		58.3		58.2	
		2.2				-0.4		
17 1/2 years	68.7				57.9			
18 years	(1)				(1)			

NOTE: $\overline{X}$ = mean, d^1 = difference between successive group means, and d^2 = difference between successive moving averages.

[1]No value is recorded for this age group since the average age of youths falling in this category was not sufficiently close to the age specified. For further discussion see p. 4.

Table 14. Weight in kilograms of males and females aged 6-18 years by quarter-year age group: differences between successive groups, 5-period moving averages of mean weights, and differences between successive moving averages, by sex, United States, 1966-70

Age	Male				Female			
	$\overline{X}$	d^1	5-period moving average	d^2	$\overline{X}$	d^1	5-period moving average	d^2
	In kilograms							
6 years	(1)				(1)			
6 1/4 years	21.38				20.73			
		0.61				0.96		
6 1/2 years	21.99				21.69			
		0.29				-0.08		
6 3/4 years	22.28		22.56		21.61		22.19	
		1.18				1.54		0.73
7 years	23.46		23.29		23.15		22.92	
		0.24		0.73		0.64		0.55
7 1/4 years	23.70		23.95		23.79		23.47	
		1.31		0.66		0.57		0.78
7 1/2 years	25.01		24.71		24.36		24.25	
		0.30		0.76		0.09		0.69
7 3/4 years	25.31		25.51		24.45		24.94	
		0.77		0.80		1.04		0.78
8 years	26.08		26.29		25.49		25.72	
		1.37		0.78		1.10		0.75
8 1/4 years	27.45		27.00		26.59		26.47	
		0.16		0.71		1.12		1.12
8 1/2 years	27.61		27.81		27.71		27.59	
		0.95		0.81		0.42		0.97
8 3/4 years	28.56		28.53		28.13		28.56	
		0.78		0.72		1.92		0.92
9 years	29.34		29.29		30.05		29.48	
		0.35		0.74		0.28		0.95
9 1/4 years	29.69		30.23		30.33		30.43	
		1.48		0.96		0.85		1.01
9 1/2 years	31.17		30.93		31.18		31.44	
		1.21		0.70		1.28		0.95
9 3/4 years	32.38		31.62		32.46		32.39	
		-0.32		0.69		0.73		0.92
10 years	32.06		32.45		33.19		33.31	
		0.73		0.83		1.59		1.04
10 1/4 years	32.79		33.11		34.78		34.35	
		1.08		0.66		0.14		0.99
10 1/2 years	33.87		34.04		34.92		35.34	
		0.60		0.93		1.50		1.11
10 3/4 years	34.47		34.88		36.42		36.45	
		2.52		0.84		0.99		1.15
11 years	36.99		35.91		37.41		37.60	
		-0.71		1.03		1.29		1.31
11 1/4 years	36.28		37.24		38.70		38.91	
		1.67		1.33		1.86		1.14
11 1/2 years	37.95		38.32		40.56		40.05	
		3.02		1.08		0.89		1.60
11 3/4 years	40.52		39.30		41.45		41.65	
		-0.67		0.98		0.69		1.39

NOTE: $\overline{X}$ = mean, d^1 = difference between successive group means, and d^2 = difference between successive moving averages.

[1] No value is recorded for this age group since the average age of youths falling in this category was not sufficiently close to the age specified. For further discussion see p. 4.

Table 14. Weight in kilograms of males and females aged 6-18 years by quarter-year age group: differences between successive groups, 5-period moving averages of mean weights, and differences between successive moving averages, by sex, United States, 1966-70—Con.

Age	Male				Female			
	$\bar{X}$	d^1	5-period moving average	d^2	$\bar{X}$	d^1	5-period moving average	d^2
	In kilograms							
12 years	39.85		40.46		42.14		43.04	
		2.04		1.16		3.26		1.61
12 1/4 years	41.89		41.82		45.40		44.65	
		0.22		1.36		0.26		1.33
12 1/2 years	42.11		42.65		45.66		45.98	
		2.63		0.83		2.93		1.61
12 3/4 years	44.74		44.37		48.59		47.59	
		-0.06		1.72		-0.46		1.04
13 years	44.68		45.94		48.13		48.63	
		3.76		1.57		2.04		1.23
13 1/4 years	48.44		48.04		50.17		49.86	
		1.30		2.10		0.43		0.71
13 1/2 years	49.74		49.84		50.60		50.57	
		2.88		1.80		1.22		0.92
13 3/4 years	52.62		52.04		51.82		51.49	
		1.12		2.20		0.33		1.05
14 years	53.74		53.82		52.15		52.54	
		1.91		1.78		0.58		0.82
14 1/4 years	55.65		55.32		52.73		53.36	
		1.71		1.50		2.68		0.55
14 1/2 years	57.36		56.63		55.41		53.91	
		-0.14		1.31		-0.72		0.62
14 3/4 years	57.22		58.19		54.69		54.53	
		1.95		1.56		-0.13		0.96
15 years	59.17		59.13		54.56		55.49	
		2.38		0.94		0.68		0.41
15 1/4 years	61.55		60.27		55.24		55.90	
		-1.22		1.14		2.32		0.35
15 1/2 years	60.33		61.53		57.56		56.25	
		2.73		1.26		-0.12		0.63
15 3/4 years	63.06		62.54		57.44		56.88	
		0.47		1.01		-1.01		0.37
16 years	63.53		63.06		56.43		57.25	
		0.69		0.52		1.29		0.57
16 1/4 years	64.22		64.08		57.72		57.82	
		-0.06		1.02		-0.63		0.11
16 1/2 years	64.16		64.69		57.09		57.93	
		1.25		0.61		3.31		0.05
16 3/4 years	65.41		65.78		60.40		57.98	
		0.70		1.09		-2.37		0.15
17 years	66.11		66.42		58.03		58.13	
		2.91		0.64		-1.39		0.13
17 1/4 years	69.02		67.55		56.64		58.76	
		-1.62		1.13		1.84		
17 1/2 years	67.40				58.48			
		2.43				-0.72		
17 3/4 years	69.83				57.76			
18 years	(1)				(1)			

NOTE: $\bar{X}$ = mean, d^1 = difference between successive group means, and d^2 = difference between successive moving averages.

[1]No value is recorded for this age group since the average age of youths falling in this category was not sufficiently close to the age specified. For further discussion see p. 4.

Table 15. Weight in kilograms of youths aged 12 years at last birthday by sex and height group in centimeters: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Sex and height	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In kilograms									
Male												
Under 130 cm	5	15	*	*	*	*	*	*	*	*	*	*
130.0-134.9 cm	4	8	*	*	*	*	*	*	*	*	*	*
135.0-139.9 cm	34	111	32.50	3.741	0.727	26.6	27.6	30.2	31.6	34.7	37.7	39.4
140.0-144.9 cm	80	241	34.28	3.635	0.601	28.1	30.0	31.8	34.1	36.5	38.6	40.7
145.0-149.9 cm	123	386	39.27	6.243	0.615	32.1	33.2	35.7	38.2	40.9	46.1	52.5
150.0-154.9 cm	156	513	42.90	6.314	0.480	34.9	36.1	38.2	42.1	46.0	51.6	56.3
155.0-159.9 cm	135	432	47.35	7.551	0.769	38.3	39.4	41.9	46.2	50.5	57.4	61.9
160.0-164.9 cm	65	201	50.82	8.735	1.388	42.1	42.7	44.9	48.4	56.0	61.1	67.1
165.0-169.9 cm	29	88	55.75	8.811	2.031	43.3	46.4	49.0	54.4	59.9	68.3	76.6
170.0-174.9 cm	8	21	62.37	4.503	1.993	54.0	58.1	60.1	61.0	66.0	69.1	69.5
175.0-189.9 cm	3	10	*	*	*	*	*	*	*	*	*	*
180.0-184.9 cm	1	2	*	*	*	*	*	*	*	*	*	*
185.0-189.9 cm	-	-	-	-	-	-	-	-	-	-	-	-
190.0-194.9 cm	-	-	-	-	-	-	-	-	-	-	-	-
195.0 cm. and over	-	-	-	-	-	-	-	-	-	-	-	-
Female												
Under 130 cm	-	-	-	-	-	-	-	-	-	-	-	-
130.0-134.9 cm	3	10	*	*	*	*	*	*	*	*	*	*
135.0-139.9 cm	12	44	29.41	3.372	0.914	25.0	25.0	26.4	28.9	32.1	34.1	34.2
140.0-144.9 cm	32	116	38.30	7.314	1.194	28.8	30.6	33.3	36.8	41.4	49.2	55.1
145.0-149.9 cm	72	258	39.78	6.205	0.975	31.8	32.8	35.5	38.5	42.8	48.3	50.6
150.0-154.9 cm	147	517	44.00	7.421	0.677	34.4	35.8	38.9	42.8	47.4	52.9	57.4
155.0-159.9 cm	144	525	48.74	8.369	0.714	37.9	39.2	43.0	46.8	53.8	60:7	63.5
160.0-164.9 cm	95	336	53.06	8.010	0.658	42.5	43.9	47.2	51.1	57.2	65.6	69.6
165.0-169.9 cm	31	117	54.89	7.022	1.384	43.9	47.1	50.4	53.1	59.7	64.5	71.3
170.0-174.9 cm	11	42	63.66	14.501	6.214	48.7	50.1	50.8	56.7	82.2	86.0	86.1
175.0-179.9 cm	-	-	-	-	-	-	-	-	-	-	-	-
180.0-184.9 cm	-	-	-	-	-	-	-	-	-	-	-	-
185.0-189.9 cm	-	-	-	-	-	-	-	-	-	-	-	-
190.0-194.9 cm	-	-	-	-	-	-	-	-	-	-	-	-
195.0 cm. and over	-	-	-	-	-	-	-	-	-	-	-	-

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 16. Weight in pounds of youths aged 12 years at last birthday by sex and height group in inches: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Sex and height	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In pounds									
Male												
Under 51.18 in--------	5	15	*	*	*	*	*	*	*	*	*	*
51.18-53.15 in--------	4	8	*	*	*	*	*	*	*	*	*	*
53.15-55.12 in--------	34	111	71.65	8.248	1.603	54.6	60.8	66.6	69.7	76.5	83.1	86.9
55.12-57.09 in--------	80	241	75.57	8.014	1.325	61.9	66.1	70.1	75.2	80.5	85.1	89.7
57.09-59.06 in--------	123	386	86.58	13.764	1.356	70.8	73.2	78.7	84.2	90.2	101.6	115.7
59.06-61.02 in--------	156	513	94.58	13.920	1.058	76.9	79.6	84.2	92.8	101.4	113.8	124.1
61.02-62.99 in--------	135	433	104.39	16.647	1.695	84.4	86.9	92.4	101.9	111.3	126.5	136.5
62.99-64.96 in--------	65	201	112.04	19.257	3.060	92.8	94.1	99.0	106.7	123.5	134.7	147.9
64.96-66.93 in--------	29	88	122.91	19.425	4.478	95.5	102.3	108.0	119.9	132.1	150.6	168.9
66.93-68.90 in--------	8	21	137.50	9.927	4.394	119.0	128.1	132.5	134.5	145.5	152.3	153.2
68.90-70.87 in--------	3	10	*	*	*	*	*	*	*	*	*	*
70.87-72.83 in--------	1	2	*	*	*	*	*	*	*	*	*	*
72.83-74.80 in--------	-	-	-	-	-	-	-	-	-	-	-	-
74.80-76.77 in--------	-	-	-	-	-	-	-	-	-	-	-	-
76.77 and over--------	-	-	-	-	-	-	-	-	-	-	-	-
Female												
Under 51.18 in--------	-	-	-	-	-	-	-	-	-	-	-	-
51.18-53.15 in--------	3	10	*	*	*	*	*	*	*	*	*	*
53.15-55.12 in--------	12	44	64.84	7.434	2.015	55.1	55.1	58.2	63.7	70.8	75.2	75.4
55.12-57.09 in--------	32	116	84.44	16.125	2.632	63.5	67.5	73.4	81.1	91.3	108.5	121.5
57.09-59.06 in--------	72	258	87.70	13.680	2.150	70.1	72.3	78.3	78.9	94.4	106.5	111.6
59.06-61.02 in--------	147	517	97.00	16.361	1.493	75.8	78.9	85.8	94.4	104.5	116.6	126.5
61.02-62.99 in--------	144	525	107.45	18.451	1.574	83.6	86.4	94.8	103.2	118.6	133.8	140.0
62.99-64.96 in--------	95	336	117.00	17.659	1.451	93.7	96.8	104.1	112.7	126.1	144.6	153.4
64.96-66.93 in--------	31	117	121.01	15.481	3.051	96.8	103.8	111.1	117.1	131.6	142.2	157.2
66.93-68.90 in--------	11	42	140.35	31.969	13.700	107.4	110.5	112.0	125.0	181.2	189.6	189.8
68.90-70.87 in--------	-	-	-	-	-	-	-	-	-	-	-	-
70.87-72.83 in--------	-	-	-	-	-	-	-	-	-	-	-	-
72.83-74.80 in--------	-	-	-	-	-	-	-	-	-	-	-	-
74.80-76.77 in--------	-	-	-	-	-	-	-	-	-	-	-	-
76.77 in. and over----	-	-	-	-	-	-	-	-	-	-	-	-

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. Weight in kilograms of youths aged 13 years at last birthday by sex and height group in centimeters: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Sex and height	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile 5th	10th	25th	50th	75th	90th	95th
			In kilograms									
Male												
Under 130 cm----------	-	-	-	-	-	-	-	-	-	-	-	-
130.0-134.9 cm--------	2	5	*	*	*	*	*	*	*	*	*	*
135.0-139.9 cm--------	6	25	32.62	5.624	7.716	27.2	27.6	28.9	31.0	34.9	43.1	43.2
140.0-144.9 cm--------	18	56	36.54	5.852	1.607	30.0	30.5	32.1	36.1	39.2	41.7	53.2
145.0-149.9 cm--------	65	204	39.03	5.270	0.662	32.4	33.9	36.1	37.9	41.2	44.5	46.4
150.0-154.9 cm--------	99	312	42.58	6.724	0.865	34.8	36.2	37.9	41.0	45.5	49.4	61.0
155.0-159.9 cm--------	131	421	47.27	7.482	0.717	37.8	39.2	41.7	45.8	51.1	58.7	61.7
160.0-164.9 cm--------	125	393	53.01	9.324	0.916	41.5	43.7	46.9	50.4	58.2	64.4	72.5
165.0-169.9 cm--------	91	285	55.92	8.560	0.833	46.3	47.5	49.3	53.6	59.4	69.0	75.0
170.0-174.9 cm--------	63	215	62.01	10.362	1.033	51.2	51.6	53.7	60.1	67.0	76.0	85.0
175.0-179.9 cm--------	19	68	67.92	12.085	3.428	56.3	57.9	60.1	63.3	70.3	88.3	89.0
180.0-184.9 cm--------	5	15	*	*	*	*	*	*	*	*	*	*
185.0-189.9 cm--------	-	-	-	-	-	-	-	-	-	-	-	-
190.0-194.9 cm--------	-	-	-	-	-	-	-	-	-	-	-	-
195.0 cm. and over----	-	-	-	-	-	-	-	-	-	-	-	-
Female												
Under 130 cm----------	-	-	-	-	-	-	-	-	-	-	-	-
130.0-134.9 cm--------	1	3	*	*	*	*	*	*	*	*	*	*
135.0-139.9 cm--------	-	-	-	-	-	-	-	-	-	-	-	-
140.0-144.9 cm--------	15	51	37.13	7.317	2.259	26.6	27.5	30.5	36.7	40.1	44.5	56.1
145.0-149.9 cm--------	47	165	42.23	6.880	0.888	34.7	35.6	38.2	40.5	44.2	53.6	57.6
150.0-154.9 cm--------	98	329	44.32	7.029	0.787	35.6	36.5	39.2	42.9	47.3	53.7	57.9
155.0-159.9 cm--------	152	499	49.75	8.757	0.699	39.1	39.9	43.8	48.4	53.8	61.0	65.9
160.0-164.9 cm--------	156	515	53.16	8.399	0.522	41.2	43.9	47.7	52.2	57.0	63.8	68.5
165.0-169.9 cm--------	86	284	58.17	9.125	0.921	46.2	47.4	52.2	58.1	61.5	69.3	76.2
170.0-174.9 cm--------	24	87	58.11	13.209	2.343	46.2	47.1	48.4	52.9	65.3	68.6	96.8
175.0-179.9 cm--------	3	10	*	*	*	*	*	*	*	*	*	*
180.0-184.9 cm--------	-	-	-	-	-	-	-	-	-	-	-	-
185.0-189.9 cm--------	-	-	-	-	-	-	-	-	-	-	-	-
190.0-194.9 cm--------	-	-	-	-	-	-	-	-	-	-	-	-
195.0 cm. and over----	-	-	-	-	-	-	-	-	-	-	-	-

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. Weight in pounds of youths aged 13 years at last birthday by sex and height group in inches: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Sex and height	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In pounds									
Male												
Under 51.18 in--------	-	-	-	-	-	-	-	-	-	-	-	-
51.18-53.15 in--------	2	5	*	*	*	*	*	*	*	*	*	*
53.15-55.12 in--------	8	25	71.91	12.399	17.011	60.0	60.8	63.7	68.3	76.9	95.0	95.2
55.12-57.09 in--------	18	56	80.56	12.902	3.543	66.1	67.2	70.8	79.6	86.4	91.9	117.3
57.09-59.06 in--------	65	204	86.05	11.618	1.460	71.4	74.7	79.6	83.6	90.8	98.1	102.3
59.06-61.02 in--------	99	312	93.87	14.824	1.907	76.7	79.8	83.6	90.4	100.3	108.9	134.5
61.02-62.99 in--------	131	421	104.21	16.495	1.581	83.3	86.4	91.9	101.0	112.7	129.4	136.0
62.99-64.96 in--------	125	393	116.87	20.556	2.019	91.5	96.3	103.4	111.1	128.3	142.0	159.8
64.96-66.93 in--------	91	285	123.28	18.872	1.837	102.1	104.7	108.7	118.2	131.0	152.1	165.3
66.93-68.90 in--------	63	215	136.71	22.844	2.277	112.9	113.8	118.4	132.5	147.7	167.6	187.4
68.90-70.87 in--------	19	68	149.72	26.643	7.557	124.1	127.6	132.5	139.6	155.0	194.7	196.2
70.87-72.83 in--------	5	15	*	*	*	*	*	*	*	*	*	*
72.83-74.80 in--------	-	-	-	-	-	-	-	-	-	-	-	-
74.80-76.77 in--------	-	-	-	-	-	-	-	-	-	-	-	-
76.77 in. and over----	-	-	-	-	-	-	-	-	-	-	-	-
Female												
Under 51.18 in--------	-	-	-	-	-	-	-	-	-	-	-	-
51.18-53.15 in--------	1	3	*	*	*	*	*	*	*	*	*	*
53.15-55.12 in--------	-	-	-	-	-	-	-	-	-	-	-	-
55.12-57.09 in--------	15	51	81.86	16.131	4.980	58.6	60.6	67.2	80.9	88.4	98.1	123.7
57.09-59.06 in--------	47	165	93.10	15.168	1.958	76.5	78.5	84.2	89.3	97.4	118.2	127.0
59.06-61.02 in--------	98	329	97.71	15.496	1.735	78.7	80.5	86.4	94.6	104.3	118.4	127.6
61.02-62.99 in--------	152	499	109.68	19.306	1.541	86.2	88.0	96.6	106.7	118.6	134.5	145.3
62.99-64.96 in--------	156	515	117.20	18.517	1.151	90.8	96.8	105.2	115.1	125.7	140.7	151.0
64.96-66.93 in--------	86	284	128.24	20.117	2.031	101.9	104.5	115.1	128.1	135.6	152.8	168.0
66.93-68.90 in--------	24	87	128.11	29.121	5.165	101.9	103.8	106.7	116.6	144.0	151.2	213.4
68.90-70.87 in--------	3	10	*	*	*	*	*	*	*	*	*	*
70.87-72.83 in--------	-	-	-	-	-	-	-	-	-	-	-	-
72.83-74.80 in--------	-	-	-	-	-	-	-	-	-	-	-	-
74.80-76.77 in--------	-	-	-	-	-	-	-	-	-	-	-	-
76.77 in. and over----	-	-	-	-	-	-	-	-	-	-	-	-

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

Table 19. Weight in kilograms of youths aged 14 years at last birthday by sex and height group in centimeters: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Sex and height	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In kilograms									
Male												
Under 130 cm----------	-	-	-	-	-	-	-	-	-	-	-	-
130.0-134.9 cm--------	-	-	-	-	-	-	-	-	-	-	-	-
135.0-139.9 cm--------	2	7	*	*	*	*	*	*	*	*	*	*
140.0-144.9 cm--------	3	13	*	*	*	*	*	*	*	*	*	*
145.0-149.9 cm--------	11	42	40.51	1.829	0.644	36.9	38.6	39.6	40.6	42.0	42.5	42.7
150.0-154.9 cm--------	45	135	43.63	6.277	1.182	36.2	37.0	39.0	41.4	48.0	51.7	55.3
155.0-159.9 cm--------	83	261	47.42	7.822	0.872	37.7	38.7	41.8	46.1	51.2	58.0	62.7
160.0-164.9 cm--------	96	299	52.28	6.785	0.584	42.5	44.0	47.5	52.1	56.3	61.5	65.1
165.0-169.9 cm--------	134	432	58.07	9.416	1.054	47.7	49.3	51.6	55.4	62.3	70.6	75.7
170.0-174.9 cm--------	144	435	62.37	11.516	1.095	49.7	51.0	55.0	59.4	65.6	79.2	86.3
175.0-179.9 cm--------	71	228	65.54	9.704	1.306	50.9	55.1	58.5	64.7	69.9	74.5	84.0
180.0-184.9 cm--------	25	81	72.44	13.014	2.298	59.6	60.0	65.1	69.4	77.0	83.0	94.3
185.0-189.9 cm--------	3	9	*	*	*	*	*	*	*	*	*	*
190.0-194.9 cm--------	1	3	*	*	*	*	*	*	*	*	*	*
195.0 cm. and over----	-	-	-	-	-	-	-	-	-	-	-	-
Female												
Under 130 cm----------	-	-	-	-	-	-	-	-	-	-	-	-
130.0-134.9 cm--------	-	-	-	-	-	-	-	-	-	-	-	-
135.0-139.9 cm--------	1	2	*	*	*	*	*	*	*	*	*	*
140.0-144.9 cm--------	2	6	*	*	*	*	*	*	*	*	*	*
145.0-149.9 cm--------	17	52	42.00	5.879	1.683	32.0	35.3	36.3	42.3	47.5	49.5	51.1
150.0-154.9 cm--------	64	196	48.26	6.797	0.926	37.7	39.2	42.5	47.9	53.3	55.9	58.8
155.0-159.9 cm--------	157	508	51.35	7.705	0.520	41.2	43.4	46.3	49.6	55.6	62.2	64.3
160.0-164.9 cm--------	186	603	54.59	8.810	0.707	43.0	45.0	48.4	53.0	59.7	66.7	70.7
165.0-169.9 cm--------	114	372	58.46	10.185	0.955	45.9	47.5	52.1	56.8	61.8	70.5	76.4
170.0-174.9 cm--------	36	121	64.37	15.821	2.814	49.2	52.1	56.2	59.8	70.5	72.9	99.4
175.0-179.9 cm--------	7	28	61.33	5.496	2.620	51.7	52.0	57.7	59.8	64.6	70.2	70.6
180.0-184.9 cm--------	2	7	*	*	*	*	*	*	*	*	*	*
185.0-189.9 cm--------	-	-	-	-	-	-	-	-	-	-	-	-
190.0-194.9 cm--------	-	-	-	-	-	-	-	-	-	-	-	-
195.0 cm. and over----	-	-	-	-	-	-	-	-	-	-	-	-

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. Weight in pounds of youths aged 14 years at last birthday by sex and height group in inches: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Sex and height	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In pounds									
Male												
Under 51.18 in--------	-	-	-	-	-	-	-	-	-	-	-	-
51.18-53.15 in--------	-	-	-	-	-	-	-	-	-	-	-	-
53.15-55.12 in--------	2	7	*	*	*	*	*	*	*	*	*	*
55.12-57.09 in--------	3	13	*	*	*	*	*	*	*	*	*	*
57.09-59.06 in--------	11	42	89.31	4.032	1.420	81.4	85.1	87.3	89.5	92.6	87.3	94.1
59.06-61.02 in--------	45	135	96.19	13.838	2.606	79.8	81.6	86.0	91.3	81.6	86.0	121.9
61.02-62.99 in--------	83	261	104.54	17.245	1.922	83.1	85.3	92.2	101.6	85.3	92.2	138.2
62.99-64.96 in--------	96	299	115.26	14.958	1.288	93.7	97.0	104.7	114.9	97.0	135.6	143.5
64.96-66.93 in--------	134	432	128.02	20.759	2.324	105.2	108.7	113.8	122.1	108.7	155.6	166.9
66.93-68.90 in--------	144	435	137.50	25.388	2.414	109.6	112.4	121.3	131.0	112.4	174.6	190.3
68.90-70.87 in--------	71	228	144.49	21.394	2.879	112.2	121.5	129.0	142.6	121.5	164.2	185.2
70.87-72.83 in--------	25	81	159.70	28.691	5.066	131.4	132.3	143.5	153.0	132.3	183.0	207.9
72.83-74.80 in--------	3	9	*	*	*	*	*	*	*	*	*	*
74.80-76.77 in--------	1	3	*	*	*	*	*	*	*	*	*	*
76.77 in. and over----	-	-	-	-	-	-	-	-	-	-	-	-
Female												
Under 51.18 in--------	-	-	-	-	-	-	-	-	-	-	-	-
51.18-53.15 in--------	-	-	-	-	-	-	-	-	-	-	-	-
53.15-55.12 in--------	1	2	*	*	*	*	*	*	*	*	*	*
55.12-57.09 in--------	2	6	*	*	*	*	*	*	*	*	*	*
57.09-59.06 in--------	17	52	92.59	12.961	3.710	70.5	77.8	80.0	93.3	104.7	109.1	112.7
59.06-61.02 in--------	64	196	106.40	14.985	2.042	83.1	86.4	93.7	105.6	117.5	123.2	129.6
61.02-62.99 in--------	157	508	113.21	16.987	1.146	90.8	95.7	102.1	109.3	122.6	137.1	141.8
62.99-64.96 in--------	186	603	120.35	19.423	1.559	94.8	99.2	106.7	116.8	131.6	147.0	155.0
64.96-66.93 in--------	114	372	128.88	22.454	2.105	101.2	104.7	114.9	125.2	136.2	155.4	168.4
66.93-68.90 in--------	36	121	141.91	34.879	6.204	108.5	114.9	123.9	131.8	155.4	160.7	219.1
68.90-70.87 in--------	7	28	135.21	12.117	5.776	114.0	114.6	127.2	131.8	142.4	154.8	155.6
70.87-72.83 in--------	2	7	*	*	*	*	*	*	*	*	*	*
72.83-74.80 in--------	-	-	-	-	-	-	-	-	-	-	-	-
74.80-76.77 in--------	-	-	-	-	-	-	-	-	-	-	-	-
76.77 in. and over----	-	-	-	-	-	-	-	-	-	-	-	-

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. Weight in kilograms of youths aged 15 years at last birthday by sex and height group in centimeters: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Sex and height	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In kilograms									
Male												
Under 130 cm----------	-	-	-	-	-	-	-	-	-	-	-	-
130.0-134.9 cm--------	-	-	-	-	-	-	-	-	-	-	-	-
135.0-139.9 cm--------	-	-	-	-	-	-	-	-	-	-	-	-
140.0-144.9 cm--------	-	-	-	-	-	-	-	-	-	-	-	-
145.0-149.9 cm--------	1	2	*	*	*	*	*	*	*	*	*	*
150.0-154.9 cm--------	10	30	45.72	8.582	3.550	35.7	39.2	42.6	44.7	46.0	48.7	76.1
155.0-159.9 cm--------	34	99	52.81	10.552	1.695	40.3	43.1	46.7	49.2	56.7	69.6	76.3
160.0-164.9 cm--------	71	206	53.01	8.417	0.986	42.7	44.1	46.9	51.5	56.3	65.3	68.8
165.0-169.9 cm--------	132	404	57.72	8.503	0.819	48.0	48.8	53.1	56.4	61.3	67.1	73.3
170.0-174.9 cm--------	176	574	62.88	8.464	0.633	51.6	53.4	56.7	61.9	67.2	72.9	78.1
175.0-179.9 cm--------	118	374	65.80	9.457	1.045	53.1	55.6	59.7	64.3	69.5	80.2	89.2
180.0-184.9 cm--------	51	144	72.00	11.928	1.724	54.6	60.3	64.4	70.2	78.4	84.4	96.6
185.0-189.9 cm--------	14	48	74.21	15.035	5.200	58.3	58.5	62.9	70.7	84.6	92.4	110.8
190.0-194.9 cm--------	6	15	83.39	16.431	10.332	66.4	66.7	69.6	73.8	103.0	105.7	106.2
195.0 cm. and over----	-	-	-	-	-	-	-	-	-	-	-	-
Female												
Under 130 cm----------	-	-	-	-	-	-	-	-	-	-	-	-
130.0-134.9 cm--------	-	-	-	-	-	-	-	-	-	-	-	-
135.0-139.9 cm--------	-	-	-	-	-	-	-	-	-	-	-	-
140.0-144.9 cm--------	2	5	*	*	*	*	*	*	*	*	*	*
145.0-149.9 cm--------	15	51	47.91	7.875	3.623	36.0	39.4	42.1	45.4	52.7	55.7	66.3
150.0-154.9 cm--------	69	242	49.69	8.895	1.190	39.1	40.6	44.3	48.1	52.8	60.5	68.3
155.0-159.9 cm--------	111	400	51.52	8.473	0.934	41.4	43.5	46.3	50.8	55.1	59.8	65.2
160.0-164.9 cm--------	137	509	57.03	10.828	0.875	45.1	47.3	50.2	55.0	60.2	71.7	77.7
165.0-169.9 cm--------	109	398	60.71	10.357	1.053	47.5	49.3	55.1	58.4	65.7	74.1	81.0
170.0-174.9 cm--------	49	188	65.27	10.730	1.880	49.7	53.6	57.2	61.2	71.6	85.3	86.4
175.0-179.9 cm--------	7	23	63.30	8.872	4.807	49.7	49.9	53.8	62.4	71.1	71.9	79.2
180.0-184.9 cm--------	3	26	*	*	*	*	*	*	*	*	*	*
185.0-189.9 cm--------	1	3	*	*	*	*	*	*	*	*	*	*
190.0-194.9 cm--------	-	-	-	-	-	-	-	-	-	-	-	-
195.0 cm. and over----	-	-	-	-	-	-	-	-	-	-	-	-

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. Weight in pounds of youths aged 15 years at last birthday by sex and height group in inches: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Sex and height	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In pounds									
Male												
Under 51.18 in--------	-	-	-	-	-	-	-	-	-	-	-	-
51.18-53.15 in--------	-	-	-	-	-	-	-	-	-	-	-	-
53.15-55.12 in--------	-	-	-	-	-	-	-	-	-	-	-	-
55.12-57.09 in--------	-	-	-	-	-	-	-	-	-	-	-	-
57.09-59.06 in--------	1	2	*	*	*	*	*	*	*	*	*	*
59.06-61.02 in--------	10	30	100.80	18.920	7.826	78.7	86.4	93.9	98.5	101.4	107.4	167.8
61.02-62.99 in--------	34	99	116.43	23.263	3.737	88.8	95.0	103.0	108.5	125.0	153.4	168.2
62.99-64.96 in--------	71	206	116.87	18.556	2.174	94.1	97.2	103.4	113.5	124.1	144.0	151.7
64.96-66.93 in--------	132	404	127.25	18.746	1.806	105.8	107.6	117.1	124.3	135.1	147.9	161.6
66.93-68.90 in--------	176	574	138.63	18.660	1.396	113.8	117.7	125.0	136.5	148.2	160.7	172.2
68.90-70.87 in--------	118	374	145.06	20.849	2.304	117.1	122.6	131.6	141.8	153.2	176.8	196.7
70.87-72.83 in--------	51	144	158.73	26.297	3.801	120.4	132.9	142.0	154.8	172.8	186.1	213.0
72.83-74.80 in--------	14	48	163.61	33.147	11.464	128.5	129.0	138.7	155.9	186.5	203.7	244.3
74.80-76.77 in--------	6	15	183.84	36.224	22.778	146.4	147.0	153.4	162.7	227.1	233.0	234.1
76.77 in. and over----	-	-	-	-	-	-	-	-	-	-	-	-
Female												
Under 51.18 in--------	-	-	-	-	-	-	-	-	-	-	-	-
51.18-53.15 in--------	-	-	-	-	-	-	-	-	-	-	-	-
53.15-55.12 in--------	-	-	-	-	-	-	-	-	-	-	-	-
55.12-57.09 in--------	2	5	*	*	*	*	*	*	*	*	*	*
57.09-59.06 in--------	15	51	105.62	17.361	7.987	79.4	86.9	92.8	100.1	116.2	122.8	146.2
59.06-61.02 in--------	69	242	109.55	19.610	2.624	86.2	89.5	97.7	106.0	116.4	133.4	150.6
61.02-62.99 in--------	111	400	113.58	18.680	2.059	91.3	95.9	102.1	112.0	121.5	131.8	143.7
62.99-64.96 in--------	137	509	125.73	23.872	1.929	99.4	104.3	110.7	121.3	132.7	158.1	171.3
64.96-66.93 in--------	109	398	133.84	22.833	2.322	104.7	108.7	121.5	128.8	144.8	163.4	178.6
66.93-68.90 in--------	49	188	143.90	23.656	4.145	109.6	118.2	126.1	134.9	157.9	188.1	190.5
68.90-70.87 in--------	7	23	139.55	19.559	10.598	109.6	110.0	118.6	137.6	156.1	158.5	174.6
70.87-72.83 in--------	3	26	*	*	*	*	*	*	*	*	*	*
72.83-74.80 in--------	1	3	*	*	*	*	*	*	*	*	*	*
74.80-76.77 in--------	-	-	-	-	-	-	-	-	-	-	-	-
76.77 in. and over----	-	-	-	-	-	-	-	-	-	-	-	-

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. Weight in kilograms of youths aged 16 years at last birthday by sex and height group in centimeters: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Sex and height	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In kilograms									
Male												
Under 130 cm----------	-	-	-	-	-	-	-	-	-	-	-	-
130.0-134.9 cm--------	-	-	-	-	-	-	-	-	-	-	-	-
135.0-139.9 cm--------	-	-	-	-	-	-	-	-	-	-	-	-
140.0-144.9 cm--------	-	-	-	-	-	-	-	-	-	-	-	-
145.0-149.9 cm--------	1	1	*	*	*	*	*	*	*	*	*	*
150.0-154.9 cm--------	4	12	*	*	*	*	*	*	*	*	*	*
155.0-159.9 cm--------	11	33	49.89	7.323	3.572	42.0	42.2	44.7	46.8	54.4	59.8	67.2
160.0-164.9 cm--------	32	108	53.09	6.459	1.273	44.2	44.9	48.2	51.4	58.0	60.9	66.1
165.0-169.9 cm--------	87	275	59.39	9.178	0.981	48.5	49.8	52.7	58.0	63.9	69.3	75.9
170.0-174.9 cm--------	166	552	62.66	7.556	0.629	51.6	53.8	57.5	61.6	67.1	73.1	78.0
175.0-179.9 cm--------	149	511	67.33	9.018	0.856	56.3	58.2	61.0	65.4	72.5	80.1	83.8
180.0-184.9 cm--------	72	227	72.38	12.485	1.993	58.3	59.3	64.4	68.9	76.5	90.2	96.9
185.0-189.9 cm--------	29	95	81.06	14.268	3.265	63.7	66.6	69.7	78.4	90.3	97.0	111.4
190.0-194.9 cm--------	3	10	*	*	*	*	*	*	*	*	*	*
195.0 cm. and over----	2	7	*	*	*	*	*	*	*	*	*	*
Female												
Under 130 cm----------	-	-	-	-	-	-	-	-	-	-	-	-
130.0-134.9 cm--------	-	-	-	-	-	-	-	-	-	-	-	-
135.0-139.9 cm--------	-	-	-	-	-	-	-	-	-	-	-	-
140.0-144.9 cm--------	2	5	*	*	*	*	*	*	*	*	*	*
145.0-149.9 cm--------	10	33	52.58	8.198	3.191	43.9	44.1	44.9	51.0	54.5	72.0	72.1
150.0-154.9 cm--------	57	178	51.79	10.457	1.053	41.4	42.0	45.8	48.9	54.1	61.5	83.3
155.0-159.9 cm--------	117	354	53.20	7.766	0.734	44.0	45.6	48.4	51.6	56.4	61.9	69.0
160.0-164.9 cm--------	160	547	57.71	11.129	1.246	46.1	47.3	51.5	55.5	61.2	69.5	75.1
165.0-169.9 cm--------	122	450	61.72	11.998	0.802	47.1	48.8	53.3	59.1	67.3	78.7	86.7
170.0-174.9 cm--------	53	170	63.61	8.734	1.126	52.9	53.8	58.1	62.1	66.8	73.8	84.2
175.0-179.9 cm--------	14	45	72.55	15.012	5.224	58.6	58.8	61.7	65.9	80.6	99.1	105.5
180.0-184.9 cm--------	1	2	*	*	*	*	*	*	*	*	*	*
185.0-189.9 cm--------	-	-	-	-	-	-	-	-	-	-	-	-
190.0-194.9 cm--------	-	-	-	-	-	-	-	-	-	-	-	-
195.0 cm. and over----	-	-	-	-	-	-	-	-	-	-	-	-

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. Weight in pounds of youths aged 16 years at last birthday by sex and height group in inches: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Sex and height	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			In pounds									
Male												
Under 51.18 in-------	-	-	-	-	-	-	-	-	-	-	-	-
51.18-53.15 in-------	-	-	-	-	-	-	-	-	-	-	-	-
53-15-55.12 in-------	-	-	-	-	-	-	-	-	-	-	-	-
55.12-57.09 in-------	-	-	-	-	-	-	-	-	-	-	-	-
57.09-59.06 in-------	1	1	*	*	*	*	*	*	*	*	*	*
59.06-61.02 in-------	4	12	*	*	*	*	*	*	*	*	*	*
61.02-62.99 in-------	11	33	109.99	16.145	7.875	92.6	93.0	98.5	103.2	119.9	131.8	148.2
62.99-64.96 in-------	32	108	117.04	14.240	2.807	97.4	99.0	106.3	113.3	127.9	134.3	145.7
64-96-66.93 in-------	87	275	130.93	20.234	2.163	106.9	109.8	116.2	127.9	140.9	152.8	167.3
66.93-68.90 in-------	166	552	138.14	16.658	1.387	113.8	118.6	126.8	135.8	147.9	161.2	172.0
68.90-70.87 in-------	149	511	148.44	19.881	1.887	124.1	128.3	134.5	144.2	159.8	176.6	184.7
70.87-72.83 in-------	72	227	159.57	27.525	4.394	128.5	130.7	142.0	151.9	168.7	198.9	213.6
72.83-74.80 in-------	29	95	178.71	31.456	7.198	140.4	146.8	153.7	172.8	199.1	213.8	245.6
74.80-76.77 in-------	3	10	*	*	*	*	*	*	*	*	*	*
76.77 in. and over---	2	7	*	*	*	*	*	*	*	*	*	*
Female												
Under 51.18 in-------	-	-	-	-	-	-	-	-	-	-	-	-
51.18-53.15 in-------	-	-	-	-	-	-	-	-	-	-	-	-
53.15-55.12 in-------	-	-	-	-	-	-	-	-	-	-	-	-
55.12-57.09 in-------	2	5	*	*	*	*	*	*	*	*	*	*
57.09-59.06 in-------	10	33	115.92	18.074	7.035	96.8	97.2	99.0	112.4	120.2	158.7	158.9
59.06-61.02 in-------	57	178	114.18	23.054	2.322	91.3	92.6	101.0	107.8	119.3	135.6	183.6
61.02-62.99 in-------	117	354	117.29	17.121	1.618	97.0	100.5	106.7	113.8	124.3	136.5	152.1
62.99-64.96 in-------	160	547	127.23	24.535	2.747	101.6	104.3	113.5	122.4	134.9	153.2	165.6
64.96-66.93 in-------	122	450	136.07	26.451	1.768	103.8	107.6	117.5	130.3	148.4	173.5	191.1
66.92-68.90 in-------	53	170	140.24	19.255	2.482	116.6	118.6	128.1	136.9	147.3	173.7	185.6
68.90-70.87 in-------	14	45	159.95	33.096	11.517	129.2	129.6	136.0	145.3	177.7	218.5	232.6
70-87-72.83 in-------	1	2	*	*	*	*	*	*	*	*	*	*
72.83-74.80 in-------	-	-	-	-	-	-	-	-	-	-	-	-
74.80-76.77 in-------	-	-	-	-	-	-	-	-	-	-	-	-
76.77 in. and over---	-	-	-	-	-	-	-	-	-	-	-	-

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. Weight in kilograms of youths aged 17 years at last birthday by sex and height group in centimeters: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Sex and height	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile 5th	10th	25th	50th	75th	90th	95th
Male			In kilograms									
Under 130 cm ---------	-	-	-	-	-	-	-	-	-	-	-	-
130.0-134.9 cm--------	-	-	-	-	-	-	-	-	-	-	-	-
135.0-139.9 cm--------	-	-	-	-	-	-	-	-	-	-	-	-
140.0-144.9 cm--------	-	-	-	-	-	-	-	-	-	-	-	-
145.0-149.9 cm--------	-	-	-	-	-	-	-	-	-	-	-	-
150.0-154.9 cm--------	1	3	*	*	*	*	*	*	*	*	*	*
155.0-159.9 cm--------	11	39	54.63	9.397	3.414	43.8	46.4	48.2	49.7	57.8	69.9	73.2
160.0-164.9 cm--------	25	81	57.75	6.503	1.355	49.7	51.1	52.5	56.9	61.6	70.1	70.8
165.0-169.9 cm--------	63	248	62.57	8.344	1.224	50.2	53.2	56.4	61.5	66.9	72.7	77.3
170.0-174.9 cm--------	115	396	67.06	11.163	0.704	53.3	55.5	59.5	64.6	71.9	80.9	91.6
175.0-179.9 cm--------	151	537	68.37	9.907	0.831	56.9	58.9	61.5	66.5	73.6	79.4	88.4
180.0-184.9 cm--------	80	297	73.31	12.454	1.335	59.6	61.0	65.1	71.2	78.4	91.8	102.7
185.0-189.9 cm--------	36	133	76.03	9.171	1.301	62.4	66.3	70.5	75.3	80.8	90.3	92.9
190.0-194.9 cm--------	7	25	81.40	10.985	7.588	62.9	62.9	67.8	87.3	90.3	90.6	90.6
195.0 cm. and over----	-	-	-	-	-	-	-	-	-	-	-	-
Female												
Under 130 cm----------	-	-	-	-	-	-	-	-	-	-	-	-
130.0-134.9 cm--------	-	-	-	-	-	-	-	-	-	-	-	-
135.0-139.9 cm--------	-	-	-	-	-	-	-	-	-	-	-	-
140.0-144.9 cm--------	2	5	*	*	*	*	*	*	*	*	*	*
145.0-149.9 cm--------	8	26	43.49	3.939	1.604	38.6	38.8	40.1	45.1	45.7	51.1	51.2
150.0-154.9 cm--------	43	151	49.96	6.508	0.827	41.6	42.3	44.6	48.9	53.5	59.2	64.1
155.0-159.9 cm--------	103	385	54.71	9.903	0.775	44.4	45.5	48.7	53.2	57.7	61.6	76.2
160.0-164.9 cm--------	133	506	57.79	10.620	1.028	46.8	48.0	50.2	55.4	61.5	72.3	82.3
165.0-169.9 cm--------	116	433	60.63	10.117	1.182	47.9	50.3	55.1	59.3	65.1	69.4	71.6
170.0-174.9 cm--------	51	186	62.18	9.132	1.407	50.6	52.9	55.5	60.2	65.7	76.1	82.7
175.0-179.9 cm--------	12	47	65.76	8.405	2.229	54.9	56.7	60.1	61.7	75.2	75.9	83.0
180.0-184.9 cm--------	1	2	*	*	*	*	*	*	*	*	*	*
185.0-189.9 cm--------	-	-	-	-	-	-	-	-	-	-	-	-
190.0-194.9 cm--------	-	-	-	-	-	-	-	-	-	-	-	-
195.0 cm. and over----	-	-	-	-	-	-	-	-	-	-	-	-

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. Weight in pounds of youths aged 17 years at last birthday by sex and height group in inches: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Sex and height	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile 5th	10th	25th	50th	75th	90th	95th
			In pounds									
Male												
Under 51.18 in--------	-	-	-	-	-	-	-	-	-	-	-	-
51.18-53.15 in--------	-	-	-	-	-	-	-	-	-	-	-	-
53.15-55.12 in--------	-	-	-	-	-	-	-	-	-	-	-	-
55.12-57.09 in--------	-	-	-	-	-	-	-	-	-	-	-	-
57.09-59.06 in--------	-	-	-	-	-	-	-	-	-	-	-	-
59.06-61.02 in--------	1	3	*	*	*	*	*	*	*	*	*	*
61.02-62.99 in--------	11	39	120.44	20.717	7.527	96.6	102.3	106.3	109.6	127.4	154.1	161.4
62.99-64.96 in--------	25	81	127.32	14.337	2.987	109.6	112.7	115.7	125,4	135.8	154.5	156.1
64.96-66.93 in--------	63	248	137.94	18.395	2.699	110.7	117.3	124.3	135.6	147.5	160.3	170.4
66.93-68.90 in--------	115	396	147.84	24.610	1.552	117.5	122.4	131.2	142.4	158.5	178.4	202.2
68.90-70.87 in--------	151	537	150.73	21.841	1.832	125.4	129.9	135.6	146.6	162.3	175.0	194.9
70.87-72.83 in--------	80	297	161.62	27.456	2.943	131.4	134.5	143.5	157.0	172.8	202.4	226.4
72.83-74.80 in--------	36	133	167.62	20.219	2.868	137.6	146.2	155.4	166.0	178.1	199.1	204.8
74.80-76.77 in--------	7	25	179.46	24.218	16.729	138.7	138.7	149.5	192.5	199.1	199.7	199.7
76.77 in and over-----	-	-	-	-	-	-	-	-	-	-	-	-
Female												
Under 51.18 in--------	-	-	-	-	-	-	-	-	-	-	-	-
51.18-53.15 in--------	-	-	-	-	-	-	-	-	-	-	-	-
53.15-55.12 in--------	-	-	-	-	-	-	-	-	-	-	-	-
55.12-57.09 in--------	2	5	*	*	*	*	*	*	*	*	*	*
57.09-59.06 in--------	8	26	95.88	8.684	3.536	85.1	85.5	88.4	99.4	100.8	112.7	112.9
59.06-61.02 in--------	43	151	110.14	14.348	1.823	91.7	93.3	98.3	107.8	117.9	130.5	141.3
61.02-62.99 in--------	103	385	120.61	21.832	1.709	97.9	100.3	107.4	117.3	127.2	135.8	168.0
62.99-64.96 in--------	133	506	127.41	23.413	2.266	103.2	105.8	110.7	122.1	127.2	159.4	181.4
64.96-66.93 in--------	116	433	133.67	22.304	2.606	105.6	110.9	121.5	130.7	143.5	153.0	157.9
66.93-68.90 in--------	51	186	137.08	20.133	3.102	111.6	116.6	122.4	132.7	144.8	167.8	182.3
68.90-70.87 in--------	12	47	144.98	18.530	4.914	121.0	125.0	132.5	136.0	165.8	167.3	183.0
70.87-72.83 in--------	1	2	*	*	*	*	*	*	*	*	*	*
72.83-74.80 in--------	-	-	-	-	-	-	-	-	-	-	-	-
74.80-76.77 in--------	-	-	-	-	-	-	-	-	-	-	-	-
76.77 in. and over----	-	-	-	-	-	-	-	-	-	-	-	-

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.

APPENDIX I

STATISTICAL NOTES

The Survey Design

The sampling plan of the third cycle of the Health Examination Survey followed a multi-stage, stratified probability sample of clusters of households in land-based segments in which a sample of the United States population (including Alaska and Hawaii) between the ages of 12 and 17 years inclusive, was selected. Excluded were those youths confined to institutions and those residing upon any of the reservation lands set aside for use of 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, eligible youth, 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 either 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 position which would have been attained if the sample had been drawn from a population stratified by age, color, and sex and makes the final sample estimates of population agree exactly with independent controls prepared by the U.S. Bureau of the Census for the noninstitutional population of the United States as of August 1, 1968 (approximate midsurvey point) by color and sex for each single year of age 12 through 17. The weights of every responding sample child in each of the 24 age, color, and sex classes are adjusted upward or downward so that the weighted total within the class equals the independent population control.

A more detailed description of the sampling plan and estimation procedures is included in *Vital and Health Statistics,* Series 2, Number 43,[26] "Sample Design and Estimation Procedures for a National Health Examination Survey of Children," and in Series 1, Numbers 1,[27] 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. 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, 14.32 percent were Negro compared with 16.03 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, 14.3 percent of the sample selected for examination was Negro in Cycle III corresponding to 14.0 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 98.3 percent to 96.1 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	98.1	90.1	97.9
13	92.5	97.7	91.1	96.8
14	91.0	95.8	89.6	96.2
15	90.7	97.8	86.4	97.5
16	89.2	95.2	86.6	93.1
17	86.5	94.7	80.2	91.6
Total	90.5	96.7	87.4	95.5

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. Note that the very worst response rate was recorded for the oldest girls, i.e., 17-year-old females.

Parameter and Variance Estimation

Because 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, the estimate of a population mean μ is computed as follows: $\bar{\bar{X}} = \Sigma W_i X_i / \Sigma W_i$; where X_i is the observation or measurement on the i^{th} person and W_i is the weight assigned to that person.

The Health Examination Survey 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 Health Examination Survey 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 Health Examination Survey because the sample, although complex in design, is relatively small (6,768 cases) and is based on only 40 strata. This feature permitted the development of a variance estimation computer program which produces tables containing desired estimates of aggregates, means, or distributions, together with a table identical in format but with the estimated variance of these 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 $\bar{X}_i$. Then, the weighted mean of the entire, undivided sample ($\bar{\bar{X}}$) 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, $\mathrm{Var}(\bar{X}) = \sum_{i=1}^{20} (\bar{X}_i - \bar{\bar{X}})^2/20$ and the standard error of the mean is simply 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 is contained in *Vital and Health Statistics,* Series 2, Number 14, "Replication: An Approach to the Analysis of Data from Complex Surveys," April 1966.[28]

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 consisted of two basic criteria. The first criteria was that a sample size of a least five was required. If this first criterion was met, then the second criterion, that the estimated coefficient of variation (i.e., the estimated standard error of the mean divided by the mean $s_{\bar{x}}/\bar{x}$ was to be less than 25 percent. 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 publications.

To illustrate these criteria, in table 16 all values of the distribution of weights for 12-year-old males between 68.9 and 70.87 inches were replaced by asterisks (*) since there were less than five people of that age, sex, and stature. In table 18, although there were five 13-year-old boys between 70.87 and 72.83 inches, the values of the distribution of weights are replaced by asterisks because the standard error with respect to the mean exceeded the criterion previously stated.

Hypothesis Testing

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 test statistic in which he would utilize the means and standard errors of the means as computed from the samples. The statistic

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

is then compared to a table of normal deviates to determine the probability of obtaining values of the test statistic as extreme or more extreme than that computed, if in fact the two population means were equal.

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 ten such tests are performed, the probability of making at least one mistake somewhere in those ten tests is closer to .50. This last "overall error rate" will get increasingly large as the number of such tests increases. Therefore, while the data necessary to do z tests are provided in the tables of this report, no such tests were performed by the authors.

It was decided, instead, to place the greatest emphasis on a relationship remaining constant over both sexes and all ages under consideration. In other words, to say that "all whole year age cohorts of males have greater statures than corresponding age cohorts of females from ages 13 to adulthood" has far greater meaning and interpretability than to say "the mean stature for 13-year-old males is significantly greater (at the .05 level) than the mean stature for 13-year-old females, and the mean stature for 14-year-old males is . . . , etc., as determined by a normal deviate." In these analyses, consistency rather than statements about successions of individual probability levels is the factor considered most important in demonstrating a relationship.

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 exluded 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 values 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 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 a 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

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

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 six youths of Cycle III of the HES whose values for height or weight on the original data tape were either missing or highly questionable.

To determine whether a height or weight 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 body weights may be an individual of extremely small stature who had a mispunched weight far too great for his stature but nevertheless within normal bounds for the entire distribution of all weights from the entire HES sample.) But the magnitude of the problem of bad or missing height and weight data in the HES is very small and oversights such as this will not have an appreciable collective effect.

By using the above described techniques of editing for questionable values and imputing the missing ones, the height values on only two subjects were changed for this report: one youth had no standing height recorded because gross distortion from birth defects made such measurement impossible and unreasonable, and the other youth was unable to stand upright because of leg braces.

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.[29] 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.

The Method of Moving Averages

A moving average enables an analyst to inspect a series of data and where necessary—especially when there appear to be irregularities due to sampling variation—to remove, or more precisely, to smooth out, some of the oscillatory movement present in the data. Moving averages have found their major applicability in the analysis of time series data where there is a constant period of oscillation, i.e., a cyclic phenomenon (for example, quarterly, semiannually, annually, etc.). In the analysis of this report there is no oscillation of fixed period. The differences between successive age groups for height and weight data are attributed to both trend and irregular elements. The moving average method attempts to smooth out the irregular (or "noise") element, leaving what is in effect the trend.

One usually chooses the length of the moving average employed to correspond with the length of the cycle present in the data. Since the data of this report have no such fixed cycle, it was arbitrarily decided that when the data are broken down by half-year intervals, a 3-period (3 half-year age groups) moving average was employed, and when quarter-year intervals are used a 5-period moving average was used instead. The choice of these periods, though arbitrary, is greater for the quarter-year analysis because the smaller intervals yield a greater amount of noise and the greater period of the moving average helps in the smoothing process.

To illustrate the mechanics of a moving average, table 6 presents 3-period moving averages applied to the half-year height data. A 3-period moving average is a series of averages which embraces first, the first three periods of a series, next, the second to the fourth periods, next, the third to the fifth periods, and so on. In table 6, the first figure for the 3-period moving average (121.5) is the arithmetic mean of the mean heights of the first three half-year age groups $[(118.3 + 121.7 + 124.5)/3 = 121.5]$. This figure is placed next to the 7-year-olds. Thus, each moving average value in table 6 is the arithmetic mean of the mean heights of three groups: the one which the moving average is entered next to as well as the groups immediately above and immediately below.

The resulting series of moving averages, it should be noted, contains fewer terms than does the original set of data. In table 6, for example, while these are means for all age groups from 6½-17½, there are moving averages only for the 7-17 age groups. Thus, it may be said that the process of moving averages consumes the values of the extreme groups in the attempt to isolate the trend by erasing the "noise" present in the data.

The higher the degree of the moving average, the more values are consumed in the process. Therefore, moving averages of smaller degrees should be used with shorter series. When the data in this study were broken down by quarter-year age groupings, the amount of noise increased due to the smaller numbers in each group (therefore, more sampling variation) and the use of a moving average of higher degree was desirable to smooth this noise. This was possible since the number of groups was large enough that even though four groups are consumed in the process (the two youngest and the two oldest), there are still enough groups left to more clearly see the trend. The procedure for computing a 5-period moving average is entirely analogous to the one described for the 3-period moving average with five groups' means being averaged instead of just three and with the first moving average being placed next to the third group's mean height. This process is done on the quarter-year age breakdowns and the resulting moving averages are shown in table 7. (Similarly, moving averages were applied to mean weights of half- and quarter-year age groups and the results are shown in tables 13 and 14.)

The method of moving averages does *not* yield a mathematical trend equation. Instead it is simply a descriptive technique which neutralizes a great deal of the noise present in any unsmoothed series of data while still following the original data up into large peaks and down into large troughs. Since a moving average shifts the specific timing of the data, it may slightly change the timing of peaks and troughs. The smaller the degree of the moving average, the smaller the effect of this shifting and with degrees of 3- or 5-periods it was felt that the effect would certainly be minimal, although the possibility of such shifts was taken into consideration in the search for "start," "end," and "peaks" of the growth spurt.

The reader should note that quarter-year data were used for distance curves while half-year data were used for velocity curves. This was done because incremental data are more subject to and affected by noise than are distance data. Thus, quarter-year groupings (smoothed by a 5-period moving average) can be used for distance since it is then both precise and relatively free of noise. However 3-period, smoothed, half-year data must be used with the velocity data since the larger age intervals make estimates more stable, decreasing the noise which would otherwise interfere with the accurate isolation of the beginning, peak, and end of the growth spurt.

Tables 6, 7, 13, and 14 display the smoothing process for both the distance and velocity curves by half- and quarter-year age intervals. The distance, or height (weight) attained, curve was smoothed by applying the appropriate moving average (3-period for half-year and 5-period for quarter-year data) to the recorded mean for each age group under consideration. The differences were then calculated between successive moving averages and can be shown to have the same values as would have resulted had a moving average technique been applied to the differences calculated from the original, unsmoothed group means. Thus, the differences between successive moving averages are, in effect, moving averages themselves of differences between the original group means.

APPENDIX II

SUPPLEMENT DISCUSSION A

Estimation of Chronologic Points on the Distance and Pseudo-Growth Curves

The technique used to arrive at the "best HES guess" for most precisely timing the important events of both the distance curves and the pseudo-velocity curves is described in this section.

The following figures tabulate the best estimated point from each of three sources for most precisely timing the two decussation points in both height and weight distance curves, i.e., from graphs and tables of full-year, half-year, quarter-year age groupings, together with "the best guess." For the pseudo-velocity curves, the same three sources were used (summarized in the boxes below) but in addition, the half-year unsmoothed data were used, both graphed in the text for illustration of the effects of smoothing and to actually help clarify both onsets and peak in analysis and in the text discussion (figures 3 and 7). Otherwise, the data grouped by half- and quarter-year intervals were always smoothed by the moving average technique. When the value fell between two plot points, the nearest point was estimated whenever possible; however, in seven instances (seen in the first two boxes summarizing the distance curves for height and for weight) an interval had to be resorted to since a decussation point could not be arrived at more precisely.

Height—Distance curves

	Female > Male	Male > Female
Full year	9½	12½ - 13½
½ year (3 pd)	9 - 9½	13 - 13½
¼ year (5 pd)	9¼	13¼
Consensus	9¼	13¼

Weight—Distance curves

	Female >Male	Male >Female
Full year	8½ - 9½	13½ - 14½
½ year (3 pd)	9	13½ - 14
¼ year (5 pd)	8¾	13½ - 13¾
Consensus	8¾	13¾

As can be easily seen, in no case is there a unanimous point selection from all three sources. The best HES guess was not arrived at by a simple average of the three sources for three reasons:

(1) It was decided that all critical points would be read to the nearest quarter-year since finer estimates were not warranted by the HES data (and many smaller fractions would have resulted).

(2) After much trial and error and "living with the data" it was felt that the three sources were not of equal precision. Therefore, a scheme for accommodating differential weighting in decision making was desirable.

(3) No graph was consistently clear for all parameters and one of the other graphs might be particularly clear at an equivocal point of another.

A best *overall* graph, i.e., maximum precision, minimum of noise, was finally settled on. The other two graphs were then used to reinforce the selection from the best graph in all circumstances and, in several cases, were invaluable in clarifying an equivocal point.

In estimating the decussation point for heights and weights from the distance curves, the quarter-year group smoothed by the 5-period moving average was selected as the overall best. In obtaining the two decussation points for height, this graph was quite clear and the other two graphs almost perfectly straddled these points. However in estimating the second point

HEIGHT

Males—Velocity Curves

	Start	Peak	End	Duration
Full year	11	13	14½	3½
½ year (3 pd)	11¾	13¼	14½	2¾
¼ year (5 pd)	11 7/8	13 5/8	14 5/8	2¾
Consensus . . .	11¾	13¼	14½	2¾

Females—Velocity Curves

	Start	Peak	End	Duration
Full year	10½	12	12½	2
½ year (3 pd)	10¼	11¾	12½	2¼
¼ year (5 pd)	10 5/8	11 7/8	12 3/8	1¾
Consensus . . .	10¼	11¾	12½	2¼

WEIGHT

Males—Velocity Curves

	Start	Peak	End	Duration
Full year	12	13	15	3
½ year (3 pd)	12¼	13¾	15	2¾
¼ year (5 pd)	12 3/8	13 5/8	14 7/8	2½
Consensus . . .	12¼	13¾	15	2¾

Females—Velocity Curves

	Start	Peak	End	Duration
Full Year	10½	12	13	2½
½ year (3 pd)	10¾	12¼	13¼	2½
¼ year (5 pd)	10 7/8	12 1/8	13¼	2 3/8
Consensus . . .	10¾	12¼	13¼	2½

for weight data, i.e., when boys get heavier than girls, the estimated point fell exactly between the 13½ and the 13¾ year groupings. Rather than picking 13 5/8, the other two graphs both estimated nearer 13¾ than 13½, so the upper end of the interval (13¾) was picked.

The pseudo-velocity curves which are presented here in box score form were more difficult to work with. As frequently pointed out in the text, these curves are neither conceptually nor technically as accurate or as valid as the distance curves. Furthermore, except for the estimated timing of *peak velocity,* all of the remaining parameters used to quantify the growth curve in this report are more or less distorted from the true estimate which could have been derived from a large group of carefully obtained individual growth curves. When these individual values are averaged or regrouped by realigning them to make the peak velocities coincide, almost all problems of difference in phasing are removed.

Accordingly, this sophisticated guessing game was more difficult for the adolescent growth spurt parameters defined in the text. The data from the full-year groups were so insensitive as to be almost worthless and were included both to be consistent with the distance curves and to emphatically illustrate their insensitivity at the growth spurt. (The graph of *unsmoothed* half-year intervals, figure 3, was helpful in picking the onset of height spurt in boys.) The graphs of the smoothed half-year intervals were selected as the overall most sensitive and yet were noise free enough to be readable. The actual values from these two graphs were finally used in all cases—but only after several exercises in clarification for height pseudo velocities.

Determining the onset was difficult in all cases; when this was settled, the ending (by our operational definition of "the decreasing velocity reaching the same rate which determined the onset") and the duration were surprisingly easy to determine and were very consistent from each of the three or four sources.

From a quick glance at figure 4, one could easily pick 11¼, 11¾, or 12¼ (or possibly even

9¼ years) as starting an upward trend directly leading to the peak in boys. However, figure 5 immediately corrects that impression because a fairly good line fits from 6 7/8 years all the way to 11 7/8 years. However, one is left with a long flat interval from 11 3/8 to 11 7/8 years (figure 5) at which the most likely true deflection occurs. From the half-year curves and the quarter-year curves, 12¼ years and 12 3/8 years are still quite good visual candidates but were finally ruled out by two considerations: (1) The two best fitted straight lines (a) the horizontal one from the early years and (b) one falling back down from the upward slope intersect better at 11¾ years than at 12¼ years and (2) by analogy, the boys' peak is, with certainty, 1½ years later than the girls' and the girls' onset at 10¼ years is a bit more clearly seen than is the boys'. If there is a rather constant relation in both sexes between onset and peak, then the girls' onset at 10¼ plus 1½ years yields 11¾ years.

But it must be emphasized that the girls' onset was only slightly more clearly determined. A case could also be made for the girls' onset at about 10¾ years (in which case, by analogy, the boys' onset should shift to 12¼ years as the best estimate). To repeat from the text, the timing of onset is somewhat equivocal from these cross-sectional HES data.

SUPPLEMENTAL DISCUSSION B

Estimation of Final Adult Height and Weight

In both the United States and Great Britain, there is ample evidence that enough girls have ceased increasing in stature by age 17 that there is no further increment in mean heights. This occurs in the HES sample after age 16. In Cycle I (adults 18-79 years) in 1960-62, the two youngest age classifications by which the data were grouped were 18-24 years (mean about 21½ years) and 25-34 years (mean at 30 years). In these two groups there was essentially no increase in either standing height or sitting height between 21½ years and 30 years; average stature was 63.8 inches at 21½ and 63.7 at 30, while sitting height was 33.6 inches at 21½ and 33.7 inches at 30 in females.

The 17½-year-old girls in Cycle III had a mean height of 64.1 inches. The examinations took place in 1966-70 (mean, 1968) so these girls will be 21½ in 1972. This is 11 years after the mean of the 1960-62 examinations for Cycle I. Because of the secular trend to increasing size, the best predicted height for 17½-year-old Cycle III girls by age 21½ is not the 63.7 or 63.8 inches found in 1961 but adjusted upward for secular trend. In Series 11, No. 104, adapting data from Meredith,[8] a rather constant secular trend was reported for 10-year-old boys in North America over a 90-year span prior to 1965 at 0.13 cm. per year. If that projection pertained here, then 0.13 cm. x 11 years = 1.43 cm. (0.56 inches) would be the adjusted female height. But there are three important considerations if that extrapolation were to be made: (1) Has the secular trend continued at a constant rate since 1965? (2) Do 10-year-olds represent what's going on at all ages? (Meredith's model does not necessarily reflect completely an adult increase because it might partially represent an earlier stage of maturation), (3) the analysis was performed on boys and not girls. Therefore, the 0.3 or 0.4 inch "increase" in United States girls (Cycle III over Cycle I in 11 years) does not appear at all unreasonable.

The estimation of the "predicted adult height of HES, Cycle III boys at 17½ years" is much more complex because their increase in stature has not ceased and there is no data beyond 17½ years (for mean year 1968). It is necessary to go outside the scope of HES Cycle III data to arrive at these estimates.

It is known from autopsy examinations in which chronologic aging of epiphyseal fusion[30] is estimated (hence the end of linear growth) and from various other studies[11,31] that boys continue to increase slowly in stature until about 22-24 years of age. Most of this last increase is trunk elongation (reflected in sitting height) due to increasing size of vertebral bodies and possibly due to intervertebral disc space as well.

In examining the HES Cycle I data, it is seen that between 18.0 and 34 years (the two age groups 18-24, 25-34 with median ages 21½ and 30 respectively), there is growth continuing among enough males to increase the mean stature 0.4 inches (68.7 to 69.1 inches), the mean erect sitting height 0.2 inches (from 35.8 to 36.0 inches), and the "normal sitting height" 0.3 inches (34.1 to 34.4 inches).

The measurement of stature was taken in one examination room for Cycles I, II, and III and both erect sitting and normal sitting height were obtained in another examining room and recorded independently. The two measures, then, are highly correlated parameters but were measured and recorded separately so they are somewhat independent as data points (to check consistency of trend). (Of course erect sitting height and normal sitting height[32] are not only much more highly correlated parameters than are sitting height and stature, but they were obtained in succession by the same technician who could not help but allow one measurement to influence the other even though they were constantly admonished to keep the measurements independent, i.e., let each measurement stand on its own merits.) These two measurements were obtained in order to estimate "the slump factor in sitting" by subtracting the difference, but it gives a little bit of comfort, subjective rather than biostatistical confidence, that they do agree so highly.

It was assumed that the mean height from Cycle I (at 25-34 years) was the best final adult height for this group, if adjusted for secular trend. (As will be seen in weights, 25 years was settled on as a "fully grown man.") The 17½-year-olds in 1968 (the mean year of HES Cycle III) will be 25 in 1975, which is 14.5 years after 1961 (mean year for Cycle I); for secular trend to operate at 0.13 cm./year, a 1.9 cm. increase can be expected over Cycle I. This added to the 69.1 inches (175.5 cm.) estimate in Cycle I gives 177.4 cm. as best predicted final adult male height of the Cycle III youths when they reach full stature in 1975.

The entire problem of weight is more difficult to interpret partly because human weight responds to individual whims or life styles such as purposeful eating and exercise habits whereas height is much more genetically controlled and not as affected. Furthermore, as described in Series 11, No. 104,[8] when examining Meredith's data for secular change in the past 90 years for 10-year-old boys in North America, a regression line fit quite well for height, but not as well for weight (height was found to increase about 10 percent in the 90 years from 1875-1965 whereas weight increased between 15 and 30 percent).

Although weight estimates are inherently more difficult and more unstable to work with than are height estimates, the Society of Actuaries simplified the procedure of estimating final adult male height for this report. In their monumental 1959 report, *Build and Blood Pres-*

sure,[33] which culminated decades of what was described as the largest statistical study on health ever performed, they fixed on age 25 as the ideal adult (fully grown) male weight. This statistical conclusion is apparently in accord with much of the epidemiological and physiological thinking of the past two decades.[34-36] The adult male becomes "fully grown" and reaches optimal strength in his mid-twenties and calculated on a large population of men there is no further increase in the size of vital organs, bone, muscle, or connective tissue mass. This leads to the corollary: Any male increase in weight after age 25 years is assumed to be adipose tissue. (Of course, a few individuals may continue to actually grow slightly as a natural occurrence or add 20-50 pounds on skeletal muscle by a regiment of weight building, special diet, or possibly anabolic hormones, but they are too few to affect actuarial estimates.)

For this report, a secular trend adjustment for weight seemed much too speculative so the predicted mean heights (adjusted for secular trend increase) were used and the Cycle I weight by height tables were applied for the Cycle III boys. The Cycle I weight by height data (by age and sex) were used from table 1 in Series 11, No. 14.[37]

The average weight at 177.4 cm. in height was obtained for 18-24 year old men and for men 25-34 years old. An interpolation between 21½ years (the median age of 18-24 year old men) yielded a weight of 77.86 kg. for males.

No such simple conclusion has been reached on optimal adult female weight, either on a conceptual basis or on an actuarial basis. The mean weight, of women, i.e., the statistical description of what exists in the United States adult female population, not the "biologically normal" weight, keeps significantly increasing with each decade of life from the mid-teens to age 75 (Series 11, No. 8, Cycle I).[32]

The only two alternatives seemed to be: (1) Use age 25 to be consistent with males for comparable calculations; there is very little biological or actuarial rationale for this, or (2) Take weight at the time stature stabilizes, as for males.

The second alternative was chosen, so the female "adult weights" are estimated from this HES Cycle III report—exactly as were their heights.

This was the simplest thing to do operationally but it leaves the comparative analysis (p. 17-18) of proportionate achievement of adult size during their relative adolescent growth spurts with a noncomparable denominator for percent of weight obtained. There almost certainly is some increase in lean body mass in females after 17½ years (not nearly as much as in males, but *some*); yet it simply cannot be estimated from available material.

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APPENDIX III

TECHNIQUES OF MEASUREMENT QUALITY CONTROL

Equipment

Height.—Height was measured in stocking feet, with feet together, back and heels against the upright bar of the height scale, head in the Frankfort plane ("look straight ahead"), and standing erect ("stand up tall" or "stand up real straight") with some assistance and demonstration when necessary. However, there was no upward pressure exerted by the examiner on the subjects' mastoids to purposely "stretch everyone in a standard manner" as was done by Tanner and some others. It is reported that supine length, that is, the recumbent position which relieves gravitational compression of the intervertebral spaces, yields 2 cm. greater length (height) and that height with Tanner's "upward pressure technique" measures 1 cm. greater than with HES technique.

The equipment consisted of a level platform to which was attached a vertical bar with a steel tape. Attached to the vertical bar perpendicularly was the horizontal bar which was brought down *snugly* on the examinee's head. Attached to another bar in the *same plane as the horizontal measuring bar* was a Polaroid camera which records the subject's identification number next to the pointer on the scale giving a precise reading. The camera, of course, not only gives a permanent record minimizing observer and recording error, but sliding up and down with the horizontal bar and *always* being in the same plane, it completely eliminates parallax. That is, if the pointer had been in the space in front of the scale, it would have been read too high if the observer had looked up at the scale from below or too low, if read down from above. These extra efforts in quality control appear justified when the excellent level of reproducibility is noted.

Weight.—A Toledo self-balancing weight scale which mechanically printed the weight directly onto the permanent record was used. The direct printing was used to minimize observer and recording error. The scale was calibrated with a set of known weights and any necessary fine adjustments were made at the beginning of each new trailer location, i.e., approximately every month. This recorded weight was later transferred to a punched card to the nearest 0.5 pound (lb.). The total weights of all clothing worn ranged from 0.24 to 0.66 lb.; this has *not* been deducted from weights presented in this report. (The weights then are 0.24 to 0.66 lb. above nude weight recorded to the nearest 0.5 lb.) The examination clothing used throughout the year was the same so there is no seasonal variation in the effect of clothing.

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 specified quality. Therefore, one of the main purposes of a monitoring system would be to indicate whether or not the measurements produced by a certain measurement process attained the desired quality. A second major purpose would be to make possible quantitative summary descriptions of residual measurement errors to aid in the interpretation of survey data.

Perhaps the most direct monitoring system used in the Health Examination Survey was the observation of the measurement process as it was being applied to an examinee. Medical, dental, and psychological advisors from HES and other advisors and consultants regularly visited the examination center to observe examination procedures and to retrain examiners if necessary. A good example of how routine observation was used as a monitoring system can be found in the taking of body measurements. One member of the examining team, a trained anthropometrist, in addition to acting as a recorder and aiding in the positioning of the examinee, was also responsible for observing and correcting any errors in measurement technique.

As a careful and thoughtful quality control program tends to be an evolving process, the most extensive systematic monitoring for body measurements performed in any of the cycles of the Health Examination Survey was performed in Cycle III. This formal system of replicate examinations is described later in the appendix.

Replicate measurements are useful for a variety of reasons, e.g., 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 examination 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 the original measurement. This uncertainty is difficult to evaluate and most attempts 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 at a specific time. Whenever possible they were interspersed among the regular examinations. An original examination was given priority over a replicate examination in that none would be 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 the 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 it would seem that generally this bias might be 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 where a response is elicited or when due to the time lapse the true value of the measurement has changed. 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 this short period of time can only be very small and this effect may usually be neglected. For example, the previous experience is much more likely to affect the true replicability of the psychological tests and those physiologic tests requiring high levels of subject participation such as the treadmill and spirometry but for procedures in which the subject is passive, such as EKG and body 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 follow-up efforts were not as intensive as for regular examinees. This is partially the result of giving priority to regular examinees if interviewer or examination time was limited. There also appeared to be an increased frequency of 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 fact. 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; this restriction may therefore 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 by the possible differences in the errors associated with the measurements as shown by the discrepancy between two measurements on the same subject. For example, measurements may vary markedly by some demographic classification, but this is not so relevant as the question of whether or not the measurement errors vary by this classification. A similar differential in the *active* and *passive* participation of subjects, e.g., spirometry versus body measurements, is assumed to operate here also but in a different way. That is, it must be assumed that the most cooperative subjects by and large self-select themselves and that their scores are truer estimates of the variable being tested. It is thus likely that their test-retest difference would be *smaller*. On the other hand, it should also be noted that although subjects did influence measurement errors, the environment, procedures, and examiners were also highly influential in the final measurement. The consideration of these additional influences causes a completely random selection of subjects to be of somewhat less concern.

The Analysis of Replicate Data on Body Measurements

Although a variety of monitoring systems for body measurements were in effect in HES from the beginning of Cycle I, it was not until Cycle III that a formal system of recalling approximately 5 percent of the subjects already examined for a replicate examination was instituted.

Upon visiting the examination centers, body measurements were taken on 6,768 youths and these data comprise the HES findings. 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 approximately 10 youths were reexamined at each stand where replicates were done. 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. Several considerations relative to the conclusions which may be drawn from the following analysis warrant mention here.

1. Although the replicate sample of examinations was not perfectly representative of the initial examinations both because of learning and sampling bias, the data are believed to yield estimates that accurately express the order of magnitude of the residual error. As described before, the selection of replicate subjects was as follows: After the first 10 days or 2 weeks of examinations, all children who had already been examined were eligible for reexamination. Of these, children living in areas which were geographically distant were eliminated from consideration. Then a random sample of the remaining children was selected. Of these, 71 percent were actually reexamined (301 out of 424). Thus, the sample of replicates is hardly representative of the entire HES sample. In addition, children who were reexamined were perhaps different from other children in that they were youths who already made their initial examination commitments, and were willing to return for a

reexamination. Although the preceding might affect psychological and perceptual measurements, any bias for body measurements would be inconsequential. The only apparent exception might be in the case of an extremely fat child chosen for replicate measurements but who refused to be reexamined. Experience indicates that fat children, because of the excess deposition of subcutaneous tissue, are somewhat more difficult to measure accurately due to difficulties in locating landmarks and variation in soft tissue compression.

2. Since there were 11 technicians employed during Cycle III, it is of interest to ascertain whether each of the examiners had a representative number of replicate measurement sessions with respect to the number of examinations performed during the survey. It should be carefully noted that it was not possible to insure that each technician had equal chances to measure replicate examinees since the length of time various technicians were associated with the survey team varied.

The table below presents the percentage of total examinations done in the survey, the percentage of intra-examiner replicates, and the percentage of inter-examiner replicates participated in by each of the 11 technicians.

Technician Number	Percentage of Regular Cycle III Examinations	Replicate Examinations: Percentage of Intra-Examinations	Replicate 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

Clearly the above table indicates some possible sources of bias which may affect the analysis of replicate data. For example, assume technician 8 was able to replicate his own measurements but his readings were very different from the other examiners. Obviously, his results would be over-represented in the replicate analysis since he examined only 15.1 percent of all youths in the actual survey, but did 24 percent of the intra-examiner replicate examinations and 16.4 percent of the inter-examiner replicate examinations. Because of this technician's over-representation, 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 2 who did only 2.7 percent of the intra-examiner replicate measurements and 10.2 percent of the inter-examiner replicate measurements, but did 13.4 percent of all examinations in Cycle III. Thus, the various combinations of observers for the inter-examiner replicates and the proportions of intra-examiner replicates were not controlled so as to be balanced among the observers. In the survey proper, the examinations were also not proportionately distributed among the observers, by necessity, since length of time the various technicians were associated with the survey varied.

This 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 technician in Cycle III. This represents one of the inherent problems of the present replicate data and to some extent limits 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,[38] and in this context, the present systematic approach to the collection of replicate body measurement data is adequate.

Results of the Replicate Analysis on Height and Weight

The absolute differences between the first and the second examinations were computed for each child for height and weight and the results are presented below.

There were 224 youths reexamined by a technician other than the one who did the initial examination. The distributions of these differences (called inter-examiner differences) are displayed next to the distributions of differences of the 77 youths who were reexamined by the same technician (called intra-examiner differences).

Height		Inter-examiner		Intra-examiner	
d_i	d_i^2	Number	Percent	Number	Percent
0.0	0.00	15	6.7	4	5.2
0.1	0.01	31	13.8	11	14.3
0.2	0.04	28	12.5	9	11.7
0.3	0.09	21	9.4	8	10.4
0.4	0.16	18	8.0	6	7.8
0.5	0.25	20	8.9	5	6.5
0.6	0.36	20	8.9	5	6.5
0.7	0.49	18	8.0	9	11.7
0.8	0.64	10	4.5	5	6.5
0.9	0.81	10	4.5	3	3.9
1.0	1.00	7	3.1	1	1.3
1.1	1.21	5	2.2	3	3.9
1.2	1.44	7	3.1	1	1.3
1.3	1.69	3	1.3	1	1.3
1.4	1.96	4	1.8	2	2.6
1.5	2.25	1	0.4	2	2.6
1.6	2.56	0	0.0	1	1.3
1.7	2.89	2	0.9	0	0.0
1.9	3.61	1	0.4	1	1.3
2.4	5.76	1	0.4	0	0.0
2.5	6.25	1	0.4	0	0.0
10.3	106.09	1	0.4	0	0.0
Sample size, n		224	100.0	77	100.0
Mean difference, $\bar{d}$, in cm.		.563		.549	
Median in cm.		.4		.5	
Mode in cm.		.1		.1	

Weight		Inter-examiner		Intra-examiner	
d_i	d_i^2	Number	Percent	Number	Percent
0.0	0.00	36	16.1	10	13.0
0.5	0.25	44	19.6	15	19.5
1.0	1.00	48	21.4	17	22.1
1.5	2.25	26	11.6	12	15.6
2.0	4.00	24	10.7	9	11.7
2.5	6.25	19	8.5	7	9.1
3.0	9.00	14	6.2	4	5.2
3.5	12.25	6	2.7	1	1.3
4.0	16.00	3	1.3	1	1.3
4.5	20.25	2	0.9	1	1.3
5.0	25.00	1	0.4	0	0.0
5.5	30.25	1	0.4	0	0.0
Sample size, n		224	100.0	77	100.0
Mean difference, $\bar{d}$, in kg.		1.335		1.325	
Median in kg.		1.0		1.0	
Mode in kg.		1.0		1.0	

For height, the three measures of central tendency—mean, median, and modal differences—appear quite similar for the inter- and intra-examiner groups. It appears that the distributions themselves are quite similar except that there was one huge difference of 10.3 cm. recorded in the inter-examiner group and this single highly deviant difference will greatly affect the discussion to follow and should be kept in mind.

For weight, the three measures of central tendency are all quite similar (and in fact, equal for medians and modes) and no highly deviant value is present to obscure the analysis of the replicate differences.

A widely used measure of replicability is the statistic σ_e, the "technical error of measurement." It is defined as $\sigma_e = \sqrt{\Sigma d_i^2 / 2n}$, the square root of the sum of the squared differences of replicates divided by twice the number of pairs. This statistic assumes that the distribution of replicate differences is normal and that errors of all pairs can be pooled.

This statistic was calculated from the above tables for each of the four distributions under consideration and the results were as follows:

Height (Inter) : 0.681
Height (Intra) : 0.494
Weight (Inter) : 1.228
Weight (Intra) : 1.173

As expected, since each of the differences needs to be squared in the calculation of this statistic, the inter-examiner σ_e is larger than that for the intra-examiner σ_e (the inter-examiner distributions have more large values than do the intra-examiner distributions). Obviously, the squaring of the 10.3 difference for inter-examiner heights greatly affects this σ_e statistic.

Differences between such differences can be tested statistically since squaring the technical error of measurement yields a variance and thus permits the calculation of an F statistic by dividing the square of the σ_e for the inter-examiner group by the square of the σ_e for the intra-examiner group for height and then for weight. The results of this operation were as follows:

Height : F = 1.90
Weight : F = 1.10

A ratio as close as possible to unity is highly desirable for the obvious reason that this would imply that there was little technician effect present in the measurement of the variable under consideration. With 223 and 76 degrees of freedom, the above demonstrates at the .05 level of significance that there is a significant technician effect for height while there is none for weight.

The careful reader will notice, however, that if that single, highly deviant difference of 10.3 cm. in the inter-examiner distribution of heights was, in fact, an error undetectable in the imputation process, there would be no difference between the two groups for either height or weight.

A difference between the inter- and intra-examiner groups would be a possibility for stature since the technician is responsible for making sure the subject's posture is correct and in this respect there is at least a small chance of technician input. Since a Polaroid snapshot was used to verify recorded measurements there is no other possible source of error.

For weight, on the other hand, the technician has no effect other than to ask the subject to stand on the scale. Since the weight is stamped directly onto the recording form by the scale itself there is no chance for significant examiner effect. Happily, none was found, which lends more credence to the replicate analysis of Cycle III body measurements.

The above analysis has been using absolute differences without regard to directionality. Further insight into the observed replicate differences can be gained by noting whether the second measurement is larger than the first or vice versa. If it is seen that the direction of the difference is positive (i.e., the second measurement taken on each youth was, on the average, greater than the first), this would imply that a good part of the differences discussed above might be explained by continued growth of the youth between the two examining times.

Each youth was brought back to the Examination Center approximately 2 weeks after the initial examination. From tables 3 and 10 it can be reckoned that a boy would have grown an average of 0.16 cm. and increased his weight by 0.17 kg. during an average 2-week period between the ages of 12 and 18, while a girl between the same ages would be expected to increase 0.06 cm. in height and 0.08 kg. of weight during the same 2-week period. Without reference to sex or age, one would expect the average youth between 12 and 18 years (independent of sex and age) to add about 0.11 cm. of height and 0.13 kg. of weight, and relating these expected gains back to the absolute differences observed earlier between initial and replicate examination, it is seen that the expected growth values account for about 20 percent of the observed differences in height and about 10 percent of the observed differences in weight.

The analysis of the replicate data taking sign into consideration yields the following mean differences between initial and replicate examination:

MEAN DIFFERENCE BETWEEN INITIAL AND REPLICATE EXAMINATION

	Height		Weight	
	Inter	Intra	Inter	Intra
Total	+.248	+.225	+.55	+.23
Males	+.270	+.310	+.68	+.35
Females	+.221	+.067	+.39	+.02

Notice that in each case the sign of the mean difference is positive (i.e., the replicate measurement was greater than the initial measurement) and this directionality is expected due to rapid growth during adolescence. Notice that in all categories the male's growth exceeds the female's growth during the same average 2 weeks as is also expected.

In summary, height data varied by about 0.5 cm. between examinations while weight varied by about 1 kg. and this variability is partly explained by growth expected during the period of time between initial and replicate examination.

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