Monthly

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
Public Health Service
Health Resources Administration
5600 Fishers Lane
Rockville, Maryland 20852

VITAL STATISTICS REPORT

Health Examination Survey Data

FROM THE
NATIONAL CENTER FOR HEALTH STATISTICS

(HRA) 76-1120
VOL. 25, NO. 3
SUPPLEMENT
JUNE 22, 1976

NCHS GROWTH CHARTS, 1976

INTRODUCTION[a]

A National Center for Health Statistics task force has constructed new growth charts for infants and children in the United States showing weight, length (recumbent or upright), weight by length, and head circumference. Clinical use of the charts can immediately show how the growth of any child ranks in comparison with the rest of the U.S. child population of like age and sex. Their primary use is to clinically detect nutritional and growth disturbances among infants and children and to assess the comparative growth status of defined populations of children.

There were many reasons for constructing new growth charts for today's children to replace the venerable Stuart-Meredith charts from the 1940's. The National Academy of Sciences in 1974[1] urged the preparation of new charts using current National Center for Health Statistics data, augmented by other appropriate data, for the assessment of the U.S. child population, primarily for nutritional disturbances. A study group cosponsored by the American Academy of Pediatrics and the Maternal and Child Health Program of the Bureau of Community Health Services, Public Health Service, had made similar recommendations in 1971,[2] emphasizing the use of new charts in the clinical assessment of the growing infant and child. There were also urgent community service program needs of some Public Health Service agency units to be met—viz, those of the Nutritional Surveillance Program of the Center for Disease Control (CDC) and the Bureau of Community Health Services. In addition, it was important to make optimal use of the data on growth and development of children collected over the past decade by the Health Examination Surveys (HES) of the National Center for Health Statistics (NCHS), including its most recent data from the Health and Nutrition Examination Surveys (HANES). Thus an NCHS task force, consisting of experts from outside the government and from CDC and NCHS, was formed to construct new growth charts. The task force members were: R. Reed, Professor of Biostatistics, Harvard University; A. Roche, Senior Scientist, Fels Research Institute; G. Owen, Professor of Pediatrics, University of New Mexico; M. Lane, M. Nichaman, and J. Goldsby, Nutrition Surveillance, CDC; T. Drizd, J.-P. Habicht, C. Johnson, A. McDowell, and P. Hamill (chairman), Division of Health Examination Statistics, NCHS. The main results of their efforts are 14 growth charts, each with seven smoothed percentile curves drawn by the computer's "Calcomp," showing weight, length (recumbent length or standing height, here labeled as stature), weight by length, and head circumference of infants and children. In addition, their analyses of data have revealed that the long trend of increasing size and earlier maturation of U.S. children has almost ceased. This significant finding is discussed later.

The new charts were constructed not only utilizing current body measurement data but also exploiting the most recent advances in data analysis and computer technology. The data used are from either the Fels Reseach Institute, Yellow Springs, Ohio, or from the NCHS Health

[a]This report prepared by Peter V.V. Hamill, Terence A. Drizd, Clifford L. Johnson, Robert B. Reed, and Alex F. Roche.

Examination Surveys. The first group of charts, newborns to 36-month-olds, is based on body measurements collected through 1975 at Fels; the second group, children 2.0 to 18.0 years of age, is based on data collected from 1962 to 1974 by NCHS.

The NCHS task force benefited from the advice of many interested agencies and individuals, but most importantly from the availability of data, for comparative purposes, from the Preschool Nutrition Survey of more than 3,500 children ages 1-5 years, collected 1968-70 by an Ohio State University team headed by Dr. George Owen.[3]

The charts covering the period from birth to 36 months present smoothed curves for body weight by age, recumbent length by age, weight by length (assuming approximate chronologic age independence under 4.0 years), and head circumference by age. There is one set of these charts for boys and one for girls. The data for these charts were derived from the body measurements of 867 children, the majority of whom were followed longitudinally at the Fels Research Institute from birth to age 24 years by serial examination. Although the data from Fels have minor biases due to sampling limitations, these biases were judged insufficient to disqualify the use of these data, especially since there were no suitable alternative data for the first year of life. Other factors, such as the technical reliability of the measurements, the large sample size, and the availability of all the data in a computer-compatible form, more than compensated for the sampling deficiencies for the purposes of these charts.

The charts for children 2 to 18 years of age include body weight by age and stature by age, and weight by stature *for prepubescent children.*[b] (Again, there are separate charts for boys and girls.) They were constructed using NCHS data from three separate surveys: HES "Cycle II," children 6-11 years, 1962-65;[4] HES "Cycle III," youths 12-17 years, 1966-70;[5] and HANES, children 1-17 years, 1971-74 (a chronologic age subset of all the data, ages 1-74 years). Because of the similarity and efficiency of the stratified probability sample designs, the data from the three NCHS surveys could be both melded for consecutive age groupings and combined when age groups overlapped (i.e., the data on HANES children 6-17 years were "pooled" with those of HES Cycle II and also with those of HES Cycle III). The nationally representative nature of these HES data has been extensively described elsewhere.[4-10]

The seven percentile curves in each chart are based on percentile points of observed data grouped by age (5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles), which were smoothed by a *least squares cubic spline technique* developed at Purdue University by de Boor and Rice.[11] All the steps of data handling and chart production are uniquely documentable; from sampling and measurement, through data editing, and final computerized curve smoothing. In fact, the generation of the equations and the plotting of the curves may be duplicated on any large digital computer with a plotting capability. The basic scaling of the charts is metric, but for additional convenience, designations in pounds and inches are also provided subordinately.

METHOD

The measuring techniques are essentially as described in the National Academy of Sciences subcommittee report published by CDC.[1] Differences in instrumentation and technique used by the Fels Research Institute and by NCHS were only minor and have been taken into account.

Fels Data, 0-36 Months

Body weight was measured using a beam balance, regularly calibrated for accuracy. Re-

---

[b] As is discussed elsewhere, there is an assumption of approximate age independence in the relationship of weight by length from infancy until the occurrence of the marked changes in body proportions which begin in early pubescence and continue past puberty. Its most immediate practical use is for those areas of the world where accurate birth dates have not been recorded for the children being assessed. To maximize the range of the applicable population while minimizing distortion of the data by pubescent children, the curves were constructed using the following sets of HES-HANES data: all girls taller than 90 cm but shorter than 137 cm (which was the 95th stature percentile for HES girls 8.0 years of age) *and* less than 10 years old; all boys taller than 90 cm but shorter than 145 cm (which was the 95th percentile in stature of HES boys at age 9.5 years) *and* less than 11.5 years old.

cumbent lengths were obtained on most subjects from birth to 24 years of age, and twó examiners were always employed to help with the proper alignment of the subjects and to hold the younger children properly. The subject was stretched out fully on a specially constructed measuring table with the head touching the fixed headboard and flattening of any lumbar lordosis was attempted. Keeping the knees as extended as possible, the examiner brought the footboard up firmly against the soles of the feet to create a right angle at the ankle. The head circumference was taken with a steel tape placed 1 inch above the glabella in front and at the maximum diameter of the occiput. The tape was carefully kept in one horizontal plane and drawn snugly.

In this serial study, every effort was made to assure independence of observations of measurements from one visit to another. The measurers did not have access to previous data at the time of measurement. On each visit every child was measured twice (i.e., by two different anthropometrists who worked independently except when measuring recumbent length, when they worked cooperatively and also exchanged measuring roles). Interobserver differences are known to be small.

At about 2½ years of age, or when the subjects could stand erectly, stature was additionally measured, in the standard manner. Thus from approximately 3 years, most subjects had a dual set of linear measurements at almost every visit: recumbent length and stature. However, these Fels stature measurements were used only for analysis and discussion, not in the construction of the charts.

NCHS Data

Weight.—A Toledo self-balancing weight scale mechanically printed the weight directly onto a permanent record. The direct printing minimized observer and recorder error. It was later transferred to a punched card and then to magnetic tape.[c]

Stature (standing height).—Stature was measured on a stadiometer. The child was in stocking feet with feet together and back and heels against the upright bar of the stature scale, in the standard manner, as for Fels. However, the equipment was somewhat different. It consisted of a level platform to which was attached a vertical bar with a steel tape. A horizontal bar, attached to the vertical bar, 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. This objective and permanent recording eliminated parallax and reduced observer and recording error.

DISCUSSION

Curve Smoothing

The NCHS task force decided that appropriately smoothed growth curves not only look better but, if the smoothing process does not distort the basic data, they also represent reality better than unsmoothed curves do. Although mathematical techniques for systematically smoothing curves, like moving averages, have been used for many years for a variety of purposes, most growth experts have smoothed their curves by hand to minimize distorting the data by unknown mathematical factors.

Perhaps the chief disadvantage of expert smoothing by hand is that, like all great art, it is not quantifiable and not reproducible. But with the availability of iterative plotting devices combined with computers, there is the capability of systematic smoothing with checkpoints against the observed data to see if the final results reasonably represent the data. The goal is like that of the ideal noise filter for phonograph or radio: to eliminate all of the noise but none of the music—"noise" being those jagged, adventitious deviations from a smoothed line which are solely due to sampling vagaries and "music" being a true deflection representing reality (such as the upward inflection of the stature by age curves in boys just after age 11½ years due to the beginning of the adolescent growth spurt).

Two basic methods of systematic, computerized curve smoothing were considered: spline

[c]All body weight data from Fels represent nude weights; those from HES *include* light, standardized examination clothing with the following approximate weights at various ages: 0.1 lb at 1 and 2 years; 0.2 lb at 3-5 years; and progressing from 0.24 lb to 0.66 lb from 6 to 18 years of age.

polynomial smoothing of the observed percentiles and smoothing by means of the Pearson curve system using polynomials in age to estimate the first 4 moments. The first method is well-documented and readily available for computer usage, although it had not been applied to growth data before and had several limitations which would require adjustment and modification. The primary objection to this system in the beginning was that it apparently did not develop any coherent relationship between the different percentile lines.

The second system, while very sensitive to the enormous amount of information contained in the median, or central tendency, would possibly be oversensitive to outlying values (although many outliers are valid, this region usually has the greatest frequency of spurious data). This method, however, would have required much more developmental work to adapt it for the present purpose than would the more fully developed cubic spline regression technique.

It was considered that, without the constraints of time and resources, a third and better alternative might be to raise the degree of the existing spline polynomial system from cubic to quartic and thus allow a better interrelationship between the different percentile lines. However, it was realized later that the existing cubic spline technique had another strength; viz, two modes of placing the knots, either fixed or variable. Using the fixed, or constant, knot subroutine ultimately provided some parallelism and interrelationship between the percentiles.

With much trial and error (which is only feasible with a computer) and testing the resulting fits to see if they reasonably represent the data (which is only possible with the data plotter), the cubic spline technique was finally chosen and employed to the eventual satisfaction of the NCHS task force.

"Splining" is a term borrowed from carpentry and mechanics to describe a mode of joining two independent pieces by a third piece which becomes common to both. In this mathematical application the "pieces" are polynomials, of a degree n, connected at selected points (knots), each pair of successive polynomials having, at the knot, identical values of their function and of the first n-1 derivatives. Thus in the cubic spline functions used here, two cubic polynomials have the same value, the same slope or velocity, and the same acceleration at the knot where they are joined. Determining the optimal number and placement of these knots requires both knowledge of the properties of the data and pragmatic tests of the results.

As already stated, the program used in this work provides for either fixed or variable knot location (placement). With fixed knots, the program iterates to obtain a least squares fit subject to the specified locations of the knots. With variable knots, the program varies the knot locations, from an initially specified set, in order to achieve the least squares fit with the minimal residual.

The NCHS task force tested many combinations for optimally fitting the smoothed curves to the data: they repeatedly varied the number and location of the knots, using both the fixed knot and the variable knot programs, and evaluated many delineations of the various data sets. Although some general rules usually suggested at least an approximate knot selection, the best choices were ultimately made by comparing the predicted curves against concomitantly printed overlays of the observed data points and minimum residuals. The goal was to achieve maximal smoothing consonant with the least distortion of the plotted percentile points of the original, observed data. With these growth data it was found that fixed knots at the same ages for all percentiles in a given chart produced percentile lines that were not locally distorted while yielding a good fit to the observed data. For instance, in the weight by age, birth-36 months charts the knots were placed at 0, 6, 18, 36 months.

A description of this spline program, together with a listing of some of its strengths and weaknesses when applied to these kinds of data, and a full discussion of the modifications employed in the NCHS task force application will be presented in a forthcoming Series 11 report in the *Vital and Health Statistics* series.[12]

Growth Charts

Fourteen charts have been produced: four for boys 0-36 months, four for girls 0-36 months, three for boys 2 to 18 years, and three for girls 2 to 18 years. The set of charts for boys and that for girls 0-36 months were all based, after appropriate smoothing techniques, on data collected by Fels from 1929 to 1975. (The charts are shown in figures 1-8.) The charts of recumbent length by age, body weight by age, and head circumference by age are all in a traditional format and require no further explanation. However, weight by length is a new presentation. The construction of these charts, by assuming approximate chronologic age independence, pools all the data from ages 0-48 months and rearranges them in length intervals by 2 cm groupings. The seven percentiles of the distribution of the associated body weights within each 2 cm length interval are then calculated and the curves are drawn. So in clinical assessment, for any child under approximately 48 months for whom recumbent length has been actually measured, the appropriate length is found on the sex-appropriate graph. His or her body weight can be compared by percentile placement with that of all children of the same sex having a similar recumbent length.

The second group of sex-specific charts is of children 2 to 18 years (figures 9-14). These charts are based on HANES data for 2-5 years of age and the pooled HANES and HES Cycles II and III data for ages 6-17 years. The sex-specific charts of stature by age and weight by age use similar data sets, but the chart of weight by stature of the boys is somewhat different from the chart of weight by stature for girls. Because girls reach the onset of pubescence and puberty 1½ to 2 years before boys (an estimated 19 months earlier according to HES data),[5] the two data sets for "prepubescence" had to be selected and defined differently.

In construction of these weight by length charts, approximate chronologic age independence of this relationship has been assumed from birth until the marked changes in body size and proportions which occur at the pubertal growth spurt. But in cross-sectional data like HES-HANES, there are no individual growth charts which would clearly indicate when this growth spurt has started nor were data obtained on children under 12 years of age about the presence or absence of the correlated phenomena of pubescence. Consequently the truncation of the upper end of the data set could only be defined by chronologic age and body size measurements, and separately for boys and girls.

So few girls would have reached the earliest pubescent growth changes in stature or weight by 8.0 years of age that their effect on the data is negligible. (The first effects of the pubescent growth spurt of sufficient magnitude affecting enough girls to influence *cross-sectional population data* have been estimated to occur at 10.25 years.)[5] But rather than truncating the reference population at 8.0 years, an attempt was made to maximize the age range of the population for which these data are appropriate (i.e., to include *most prepubescent girls, regardless of chronologic age).* The most precocious maturers would likely be the tallest because those children who have been largest since birth tend to mature early[13] and also because those who do mature early consequently become the largest. By excluding the tallest members of the population, the chronologic age could safely be extended with very little risk of data contamination by pubescent girls. Consequently, if those girls with statures above the 95th percentile at age 8.0 years (HES data)[4] were excluded, we could allow the main group of girls to be compared safely with this cohort until chronologic age 10. Using the concomitant constraints of chronologic age and stature produced the largest data set commensurate with a very high safeguard against distortion by the somatic changes in pubescent girls.

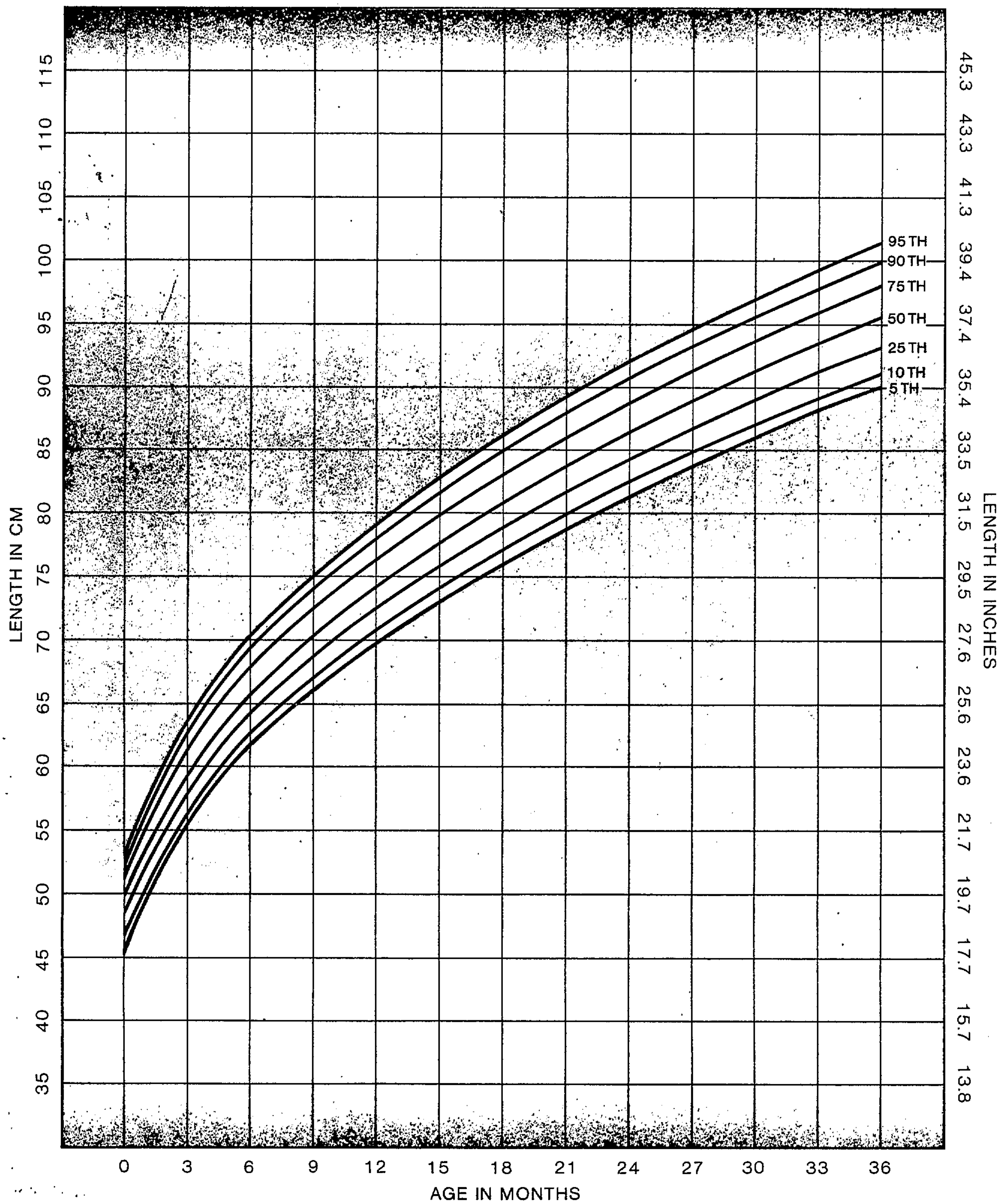
An analogous type of constraint was used to arrive at the appropriate data set for boys. But, because the boys lag behind the girls in maturity by approximately 19 months, both the chronologic age limit (11.5 years instead of 10.0 years) and the age at which the 95th height percentile[4] was chosen (9.5 years instead of 8.0 years) were placed 18 months later than those of the girls. Hence, although the data sets upon which the two charts are constructed are somewhat different (and, as can be seen comparing chart 14 with chart 13, the relevant stature range is 8 cm greater for boys than for girls), the most important biological constraint is common for both. The appearance of the earliest signs of pubescence in an individual,[d] regardless of chronologic age,

---

[d]1. Breast budding.
2. Testicular enlargement.
3. Growth, coarsening, and pigmenting of axillary and pubic hair. (Pubic hair development is frequently the most useful single indicator in field studies.)

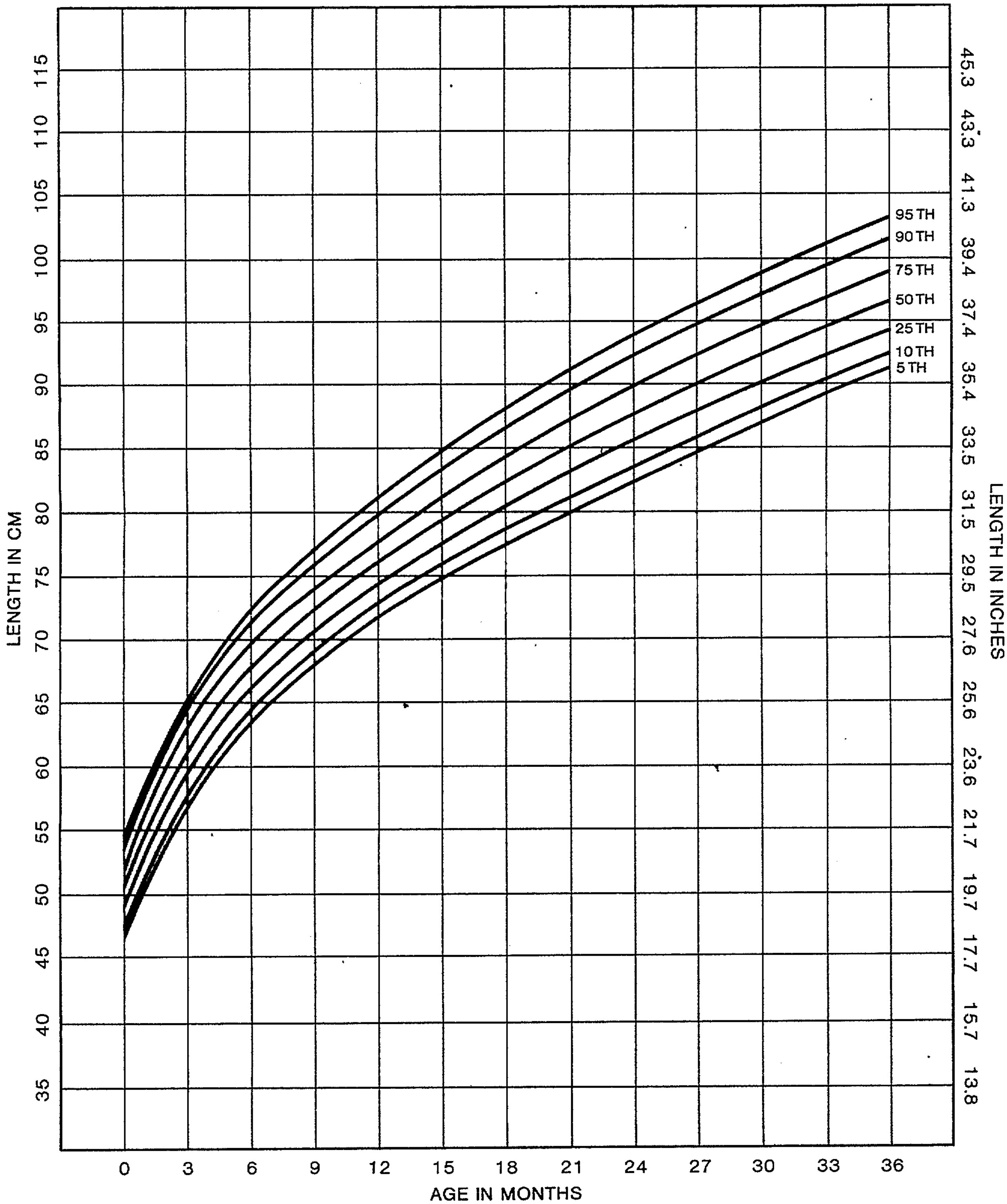
NATIONAL CENTER FOR HEALTH STATISTICS

Figure 1. Girls length by age percentiles: ages birth-36 months



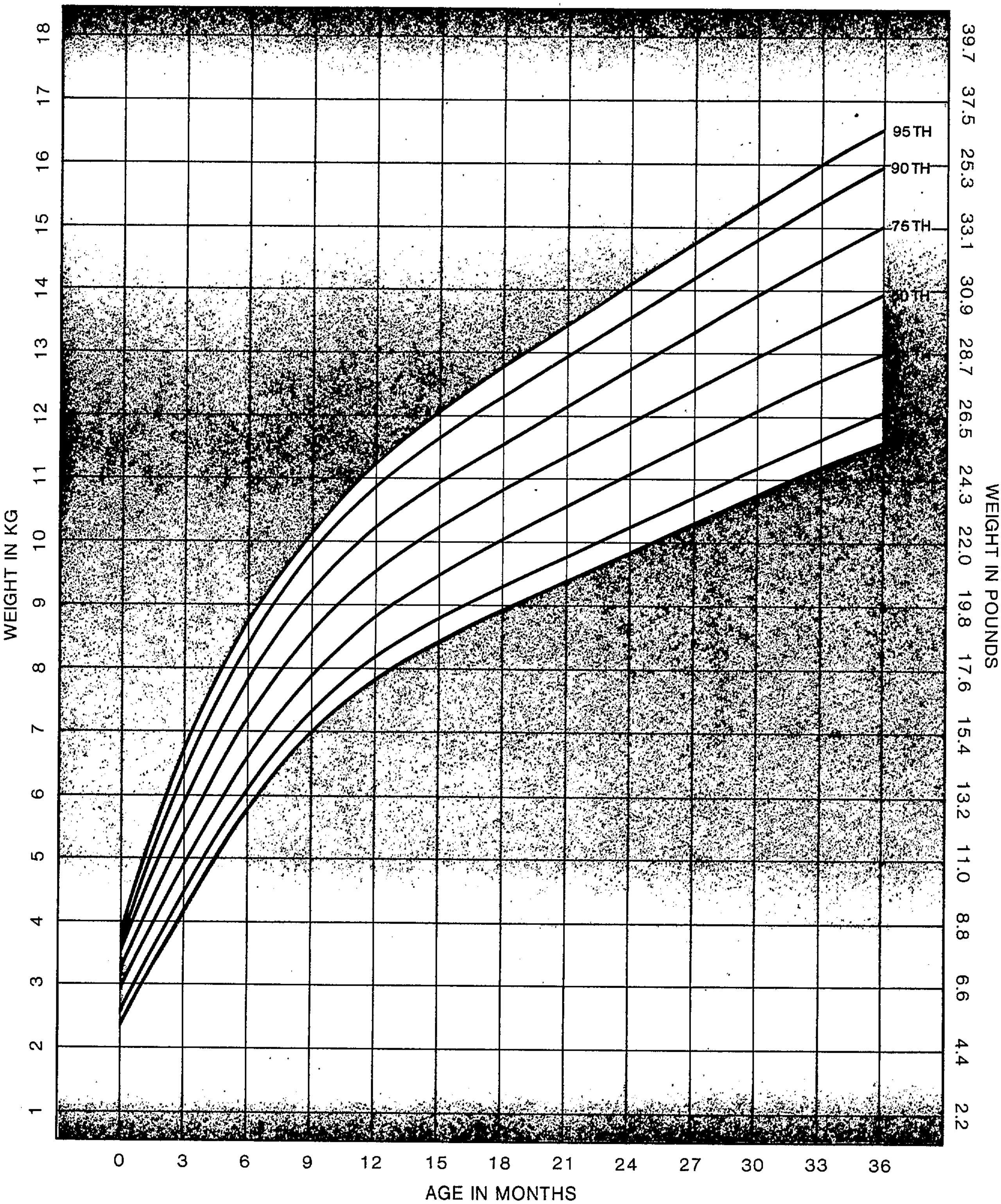
NATIONAL CENTER FOR HEALTH STATISTICS

Figure 2. Boys length by age percentiles: ages birth-36 months



NATIONAL CENTER FOR HEALTH STATISTICS

Figure 3. Girls weight by age percentiles: ages birth-36 months



NATIONAL CENTER FOR HEALTH STATISTICS

Figure 4. Boys weight by age percentiles: ages birth-36 months

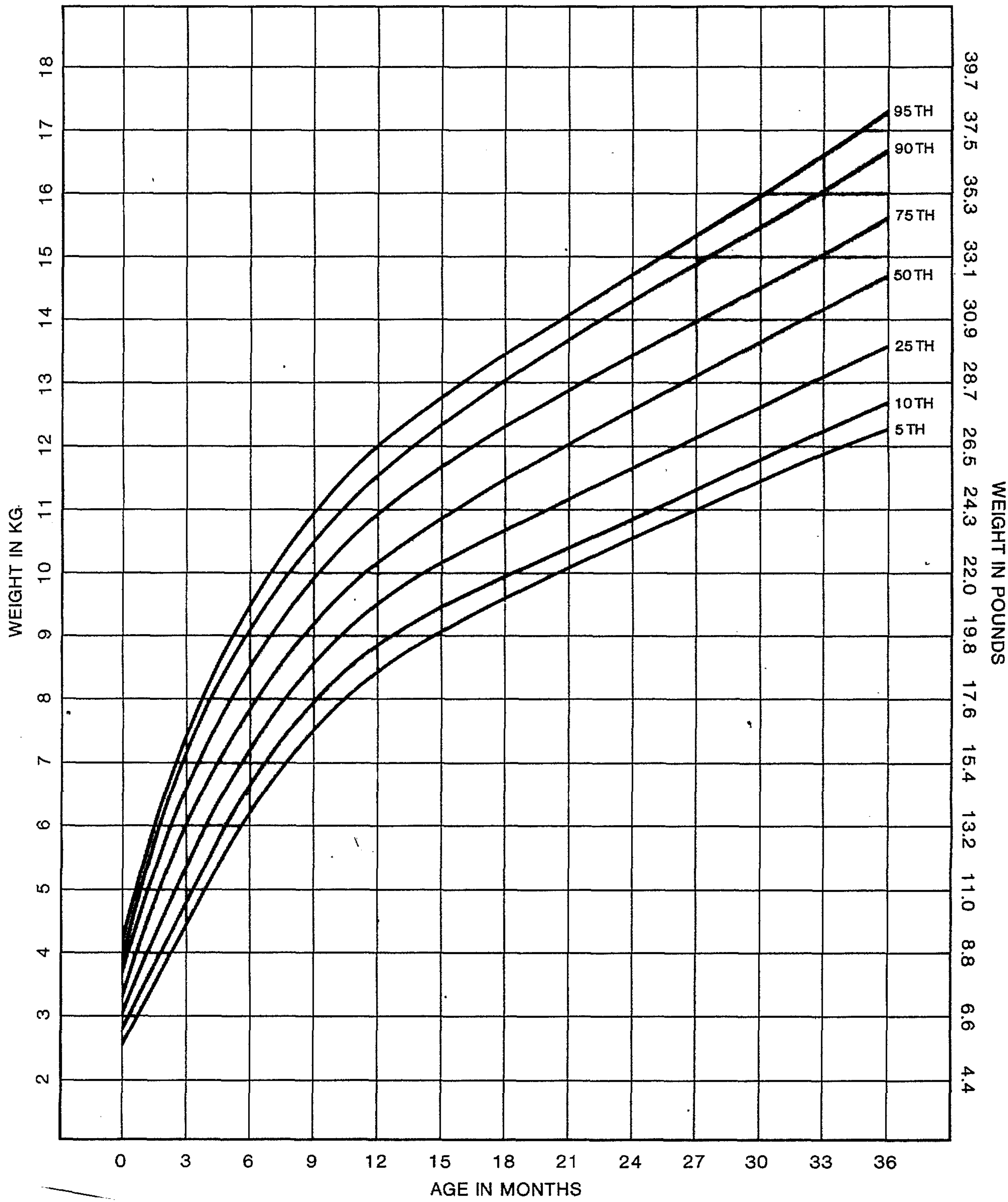


Figure 5. Girls head circumference by age percentiles: ages birth-36 months

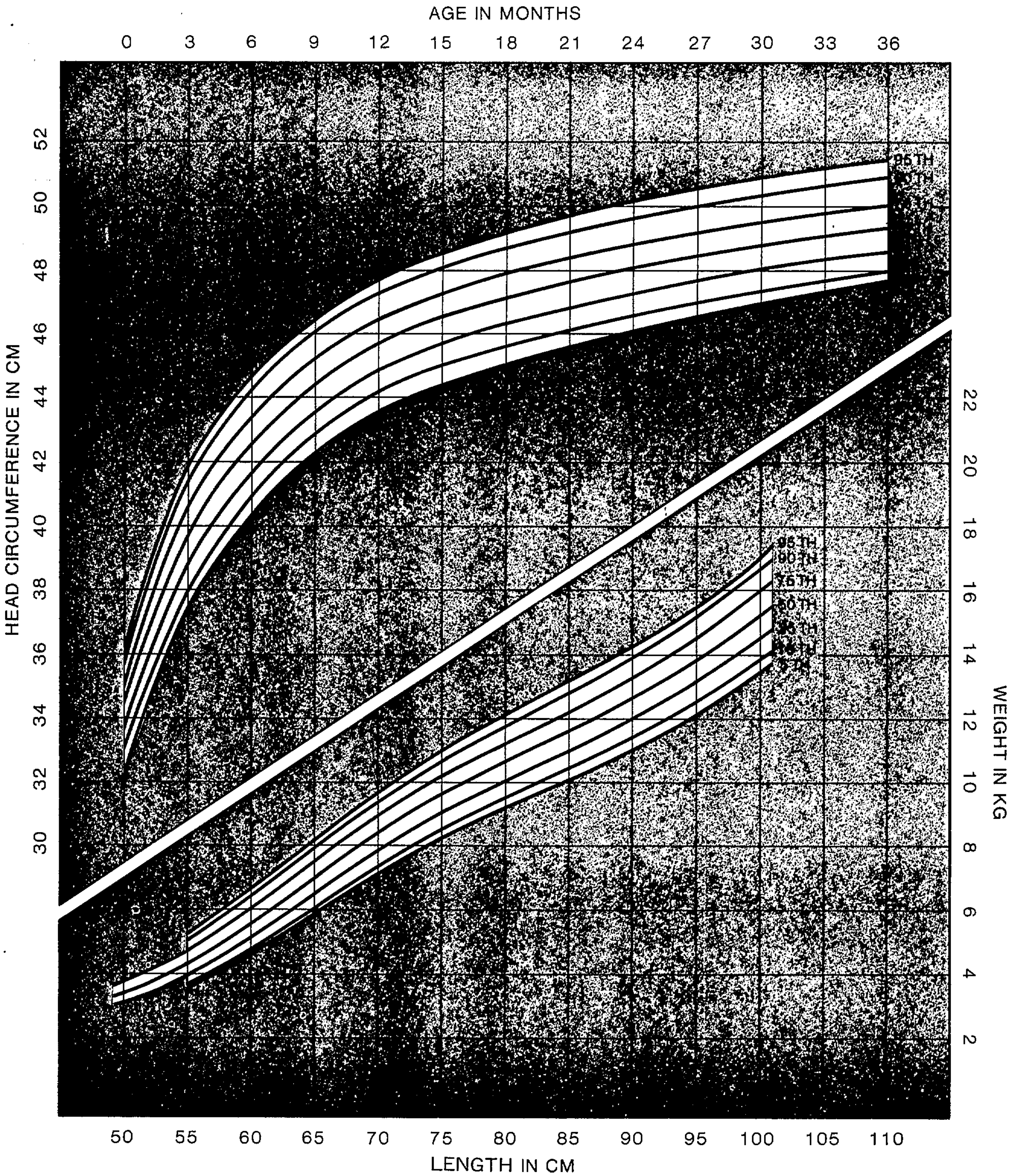


Figure 6. Girls weight by length percentiles: ages birth-36 months

Figure 7. Boys head circumference by age percentiles: ages birth-36 months

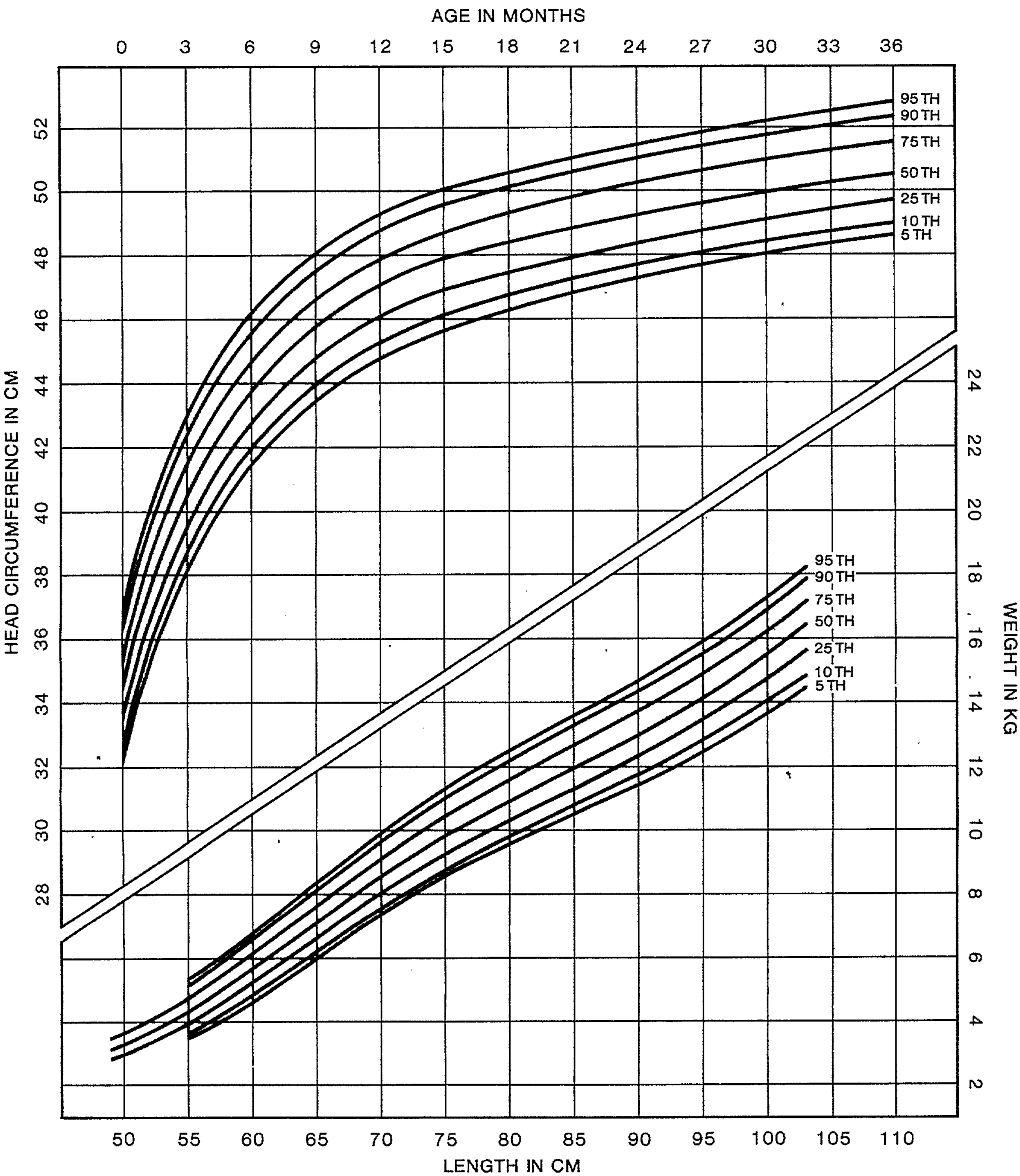
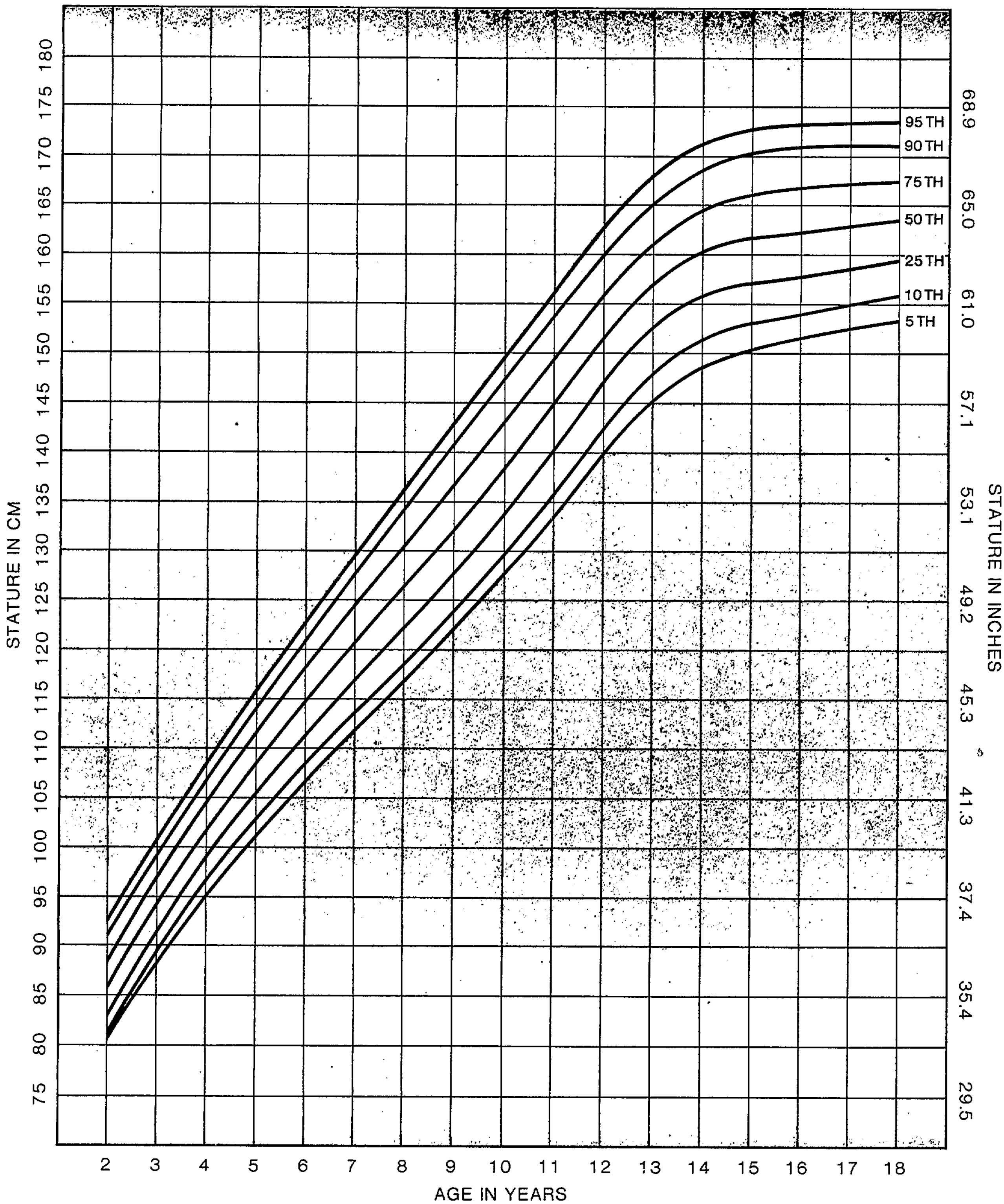


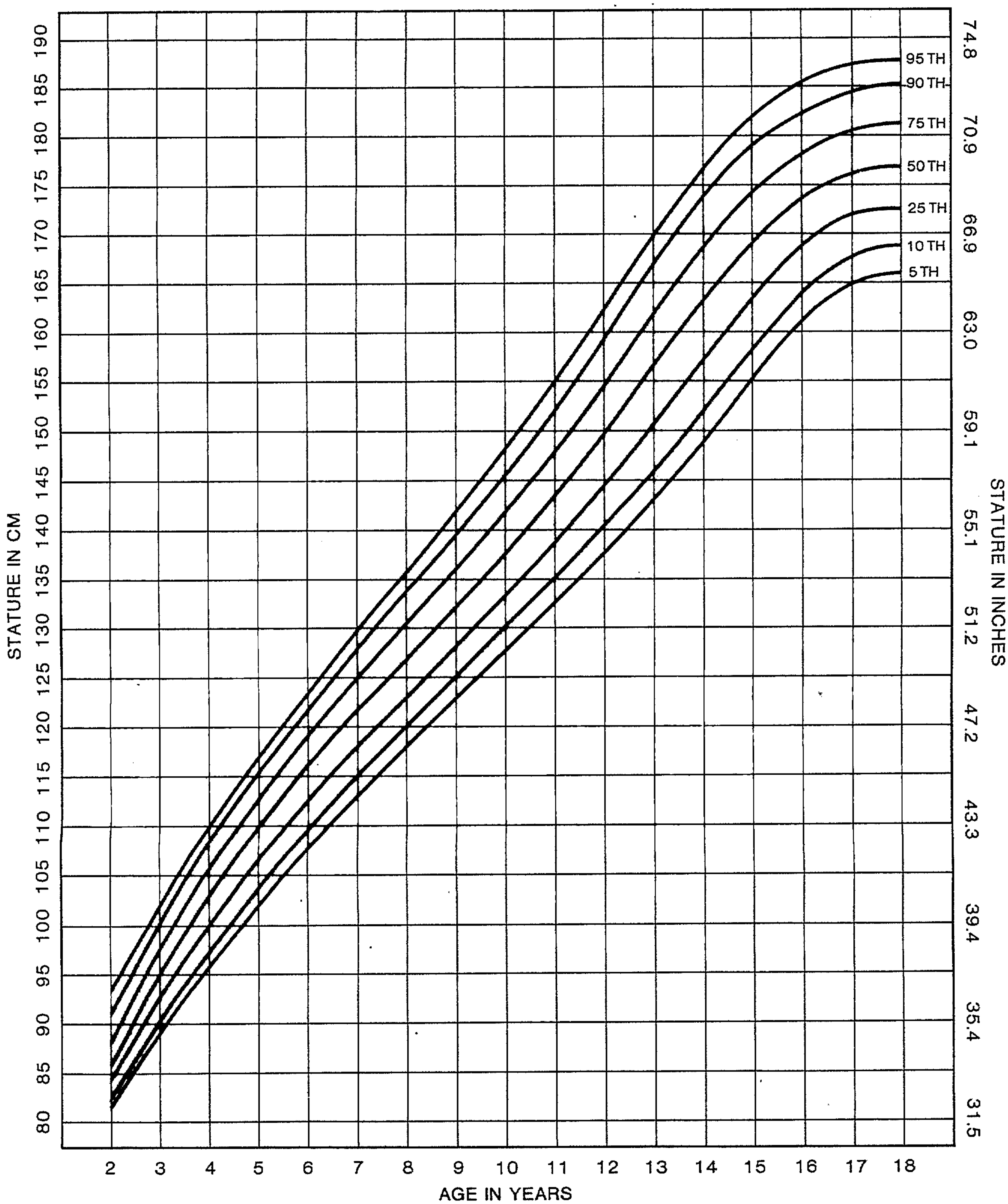
Figure 8. Boys weight by length percentiles: ages birth-36 months

Figure 9. Girls stature by age percentiles: ages 2 to 18 years



NATIONAL CENTER FOR HEALTH STATISTICS

Figure 10. Boys stature by age percentiles: ages 2 to 18 years



NATIONAL CENTER FOR HEALTH STATISTICS

Figure 11. Girls weight by age percentiles: ages 2 to 18 years

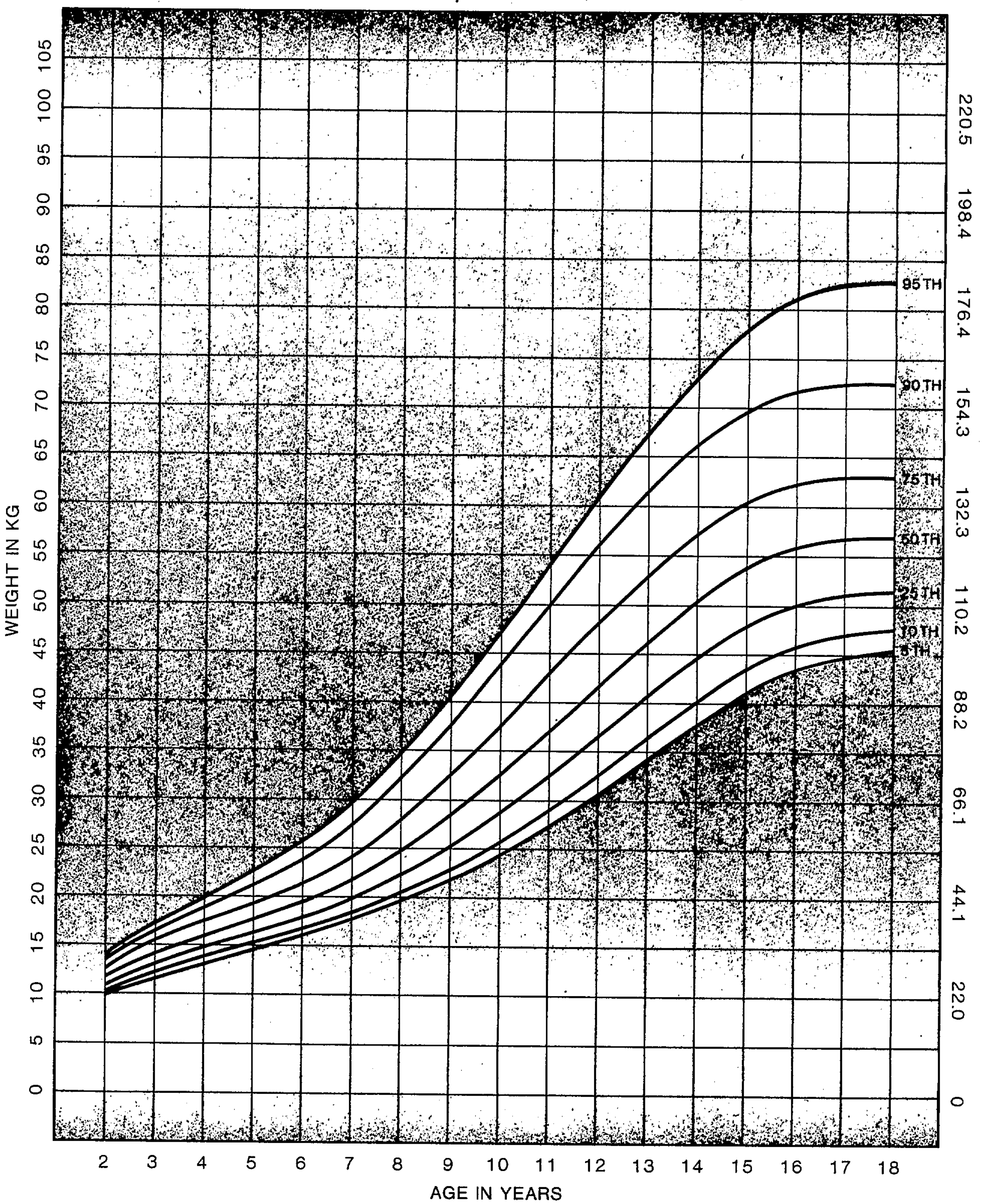
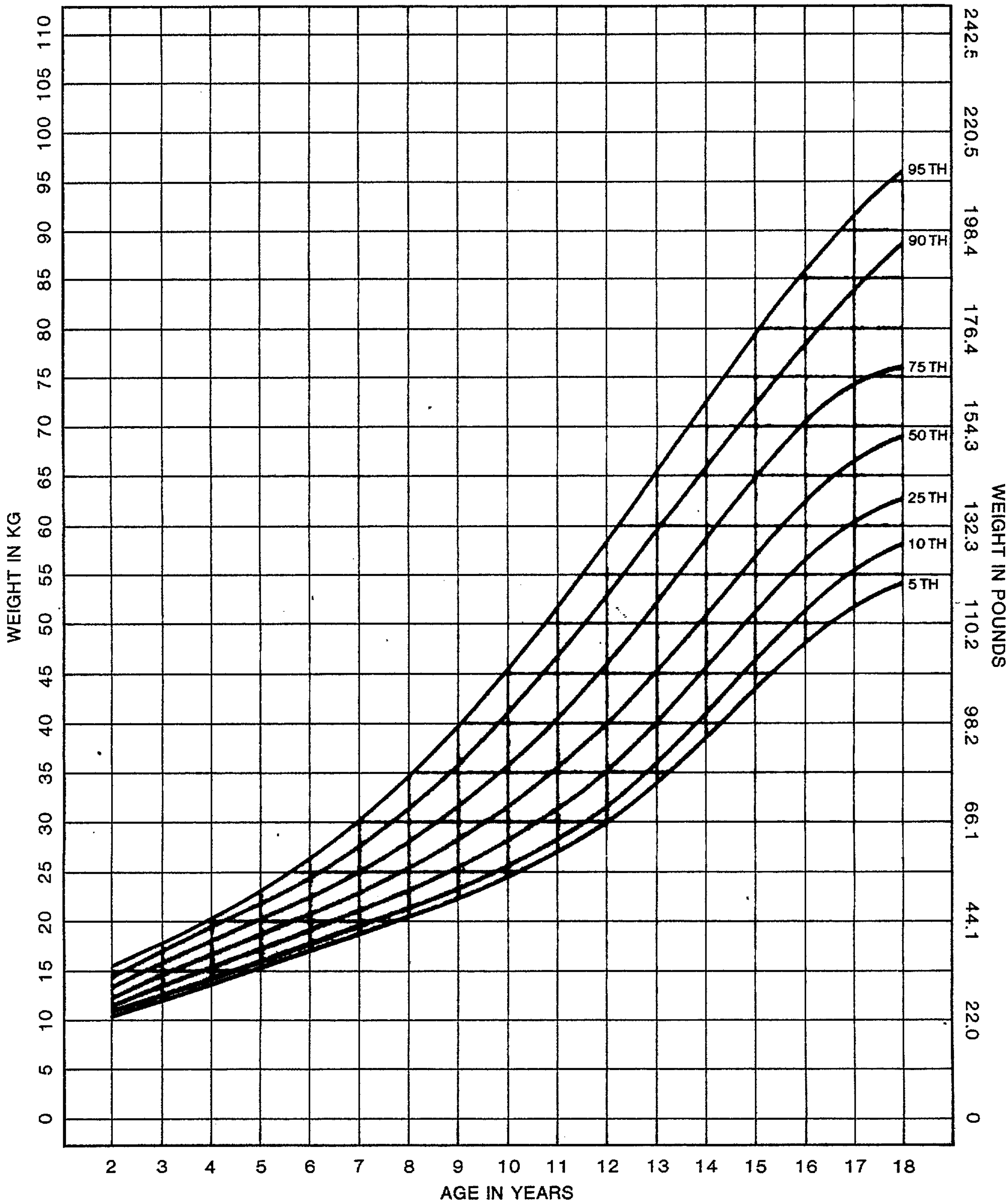
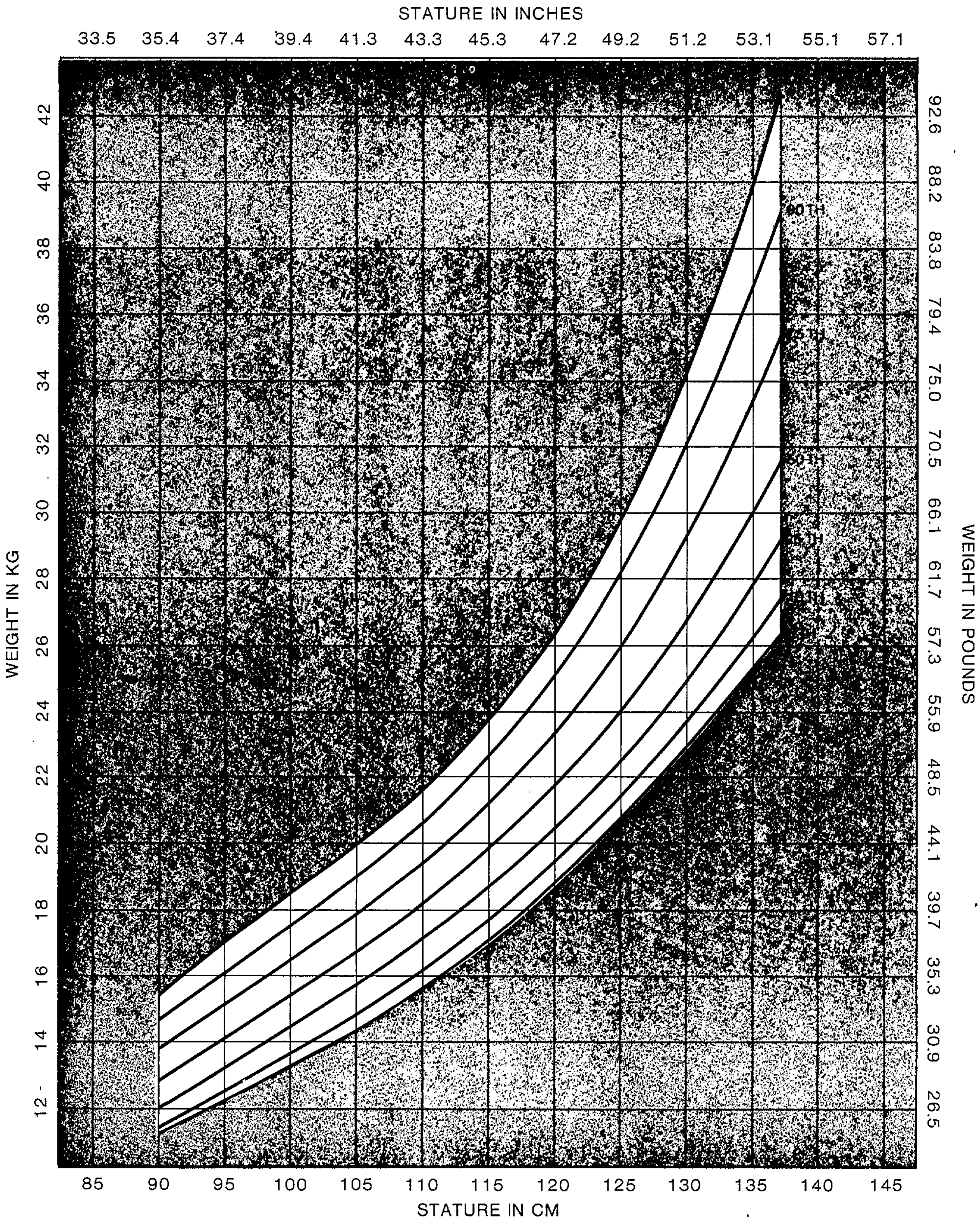


Figure 12. Boys weight by age percentiles: ages 2 to 18 years



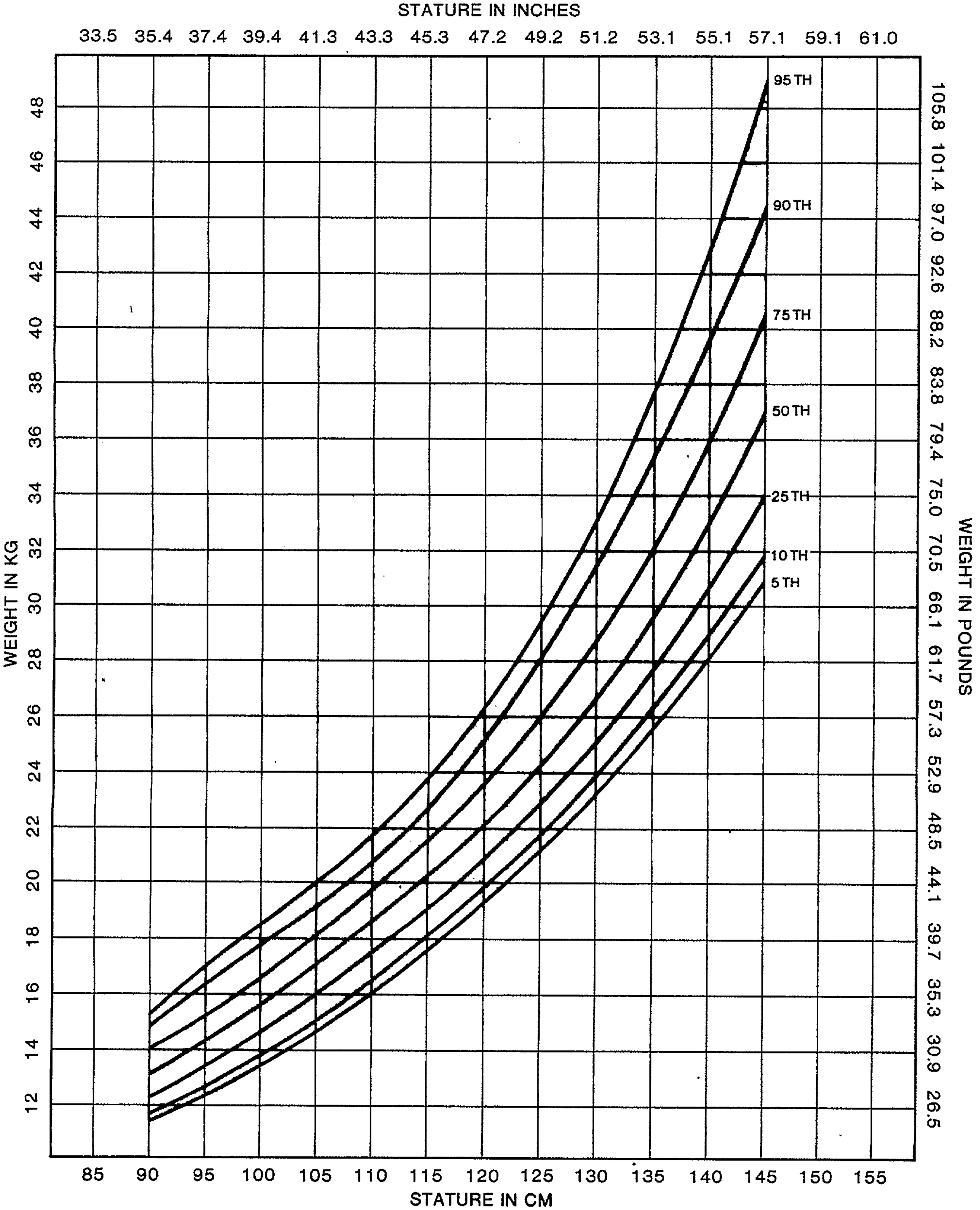
NATIONAL CENTER FOR HEALTH STATISTICS

Figure 13. Weight by stature percentiles for prepubertal girls



NATIONAL CENTER FOR HEALTH STATISTICS

Figure 14. Weight by stature percentiles for prepubertal boys



invalidates the applicability of these charts of weight by stature to that individual.

For a complex of reasons (a slight sampling problem and a possible technical problem in the two modes of measuring length, augmented by nonequivalency of the two kinds of measurements) the weight by length percentiles between ages 2 and 3 are not uniformly convertible to weight by stature percentiles. That is, if the same child were accurately measured both for stature and recumbent length, his percentile position would be somewhat different on the two charts, especially if he were quite fat. Because smoothed percentile distributions of weight by length (recumbent or upright) is a new form of growth chart, and because the decisions defining the data sets used are arbitrary (even though well defined) and require a statistical assumption of age independence which is *not quite true,* these growth charts are the most likely of all the charts presented here to require modification with future use.

Some Qualifications of the NCHS Growth Charts

Despite the very high overall quality of these sets of data, they are not uniformly perfect. The set of charts for birth to 3 years, which are based on the Fels data, have a slightly reduced variance in body weight, especially weight by length, because of limitations in the sampling design. The Fels sample was not quite as heterogeneous (i.e., it apparently had a few less extremely heavy or fat children) as would a truly representative national sample have been. The other known limitations of the charts all occur between 2.0 and 3.0 years, the overlap year in the two sets of charts. The problems are a combination of sampling and technical measurement problems, along with conceptual noncommensurability between recumbent length and stature.

Because of an administrative mistake during HANES data collection, the *stature for age data between 2.0 and 3.0 years* is a mixture of recumbent length measurements and stature measurements which inflates the data. The median error is 1.5-2.0 cm higher at age 2 than it would have been if all the measurements had been of stature (including the conditional, if all children had been capable of proper stature measurements). This discrepancy approaches zero at 2.9 years of age.

Because of both measurement and conceptual problems, the two modes of estimating length (recumbent and upright) are not equivalent. This precludes automatic conversion, or imputation, from one set of data to the other and also causes part of the noncongruence just mentioned if attempting to overlap weight by length and weight by stature charting of the same individual.

However, these epidemiologic imperfections should not limit the clinical usefulness of the charts regarding the individual child if the measurement problems and limitations are kept in mind.

Secular Trend

In the analysis of these data, the marked diminution and near cessation of the trend to constantly increasing size of successive generations of American children is the most dramatic and significant finding relating to human biology and human growth in general. This secular trend to ever-increasing size and earlier maturation, which has been such a universal finding among the countries of the Western World for the past century that it has become a good biologic index of the degree of technological and socioeconomic development of the developing countries, has been, of course, extensively discussed, many times.[4-6,14-29] From his careful comparisons of many generations of incoming Harvard students, Damon in 1968[14] was the first to seriously suggest the cessation, or at least a marked diminution, in this trend in America.

Damon's observations and those of several others[23,30,31] were limited to data from the upper socioeconomic segments of society, where the cessation apparently first occurred. The present findings both confirm those findings and extend them to include most segments of the American population.

A small but definite correlation was demonstrated in earlier NCHS data[6] between the body size of children in the U.S. and the annual income and educational level of their parents. Because the most recent data have shown a very slight increase in statures in the lower percentiles (viz, 5th and 10th, and possibly even a faint increase at the 25th percentile as well) over that of children born 5 or 10 years earlier and essential stabilization (of statures at least) for the rest of the population, it appears that a firmer statement is now warranted of Damon's speculation: "The end may be in sight."[15]

However, the precise dating of this cessation (which may be either temporary or permanent or may even yield to a reversal) is difficult because there were no data yielding reliable population estimates, such as the present ones, on the growth of children before 1962 on which to make projections. In a detailed analysis comparing that first cycle of HES children[6] with other available data (all of which had varying degrees of sampling limitations), we concluded at that time, from data collected on children born before 1950, that the secular trend, although possibly abating in America, had not yet ceased. From the analysis of our current sets of data the congruence (as seen in the table between the statures and weights of children from HES Cycles II and III and those from HANES I, born almost 10 years later) is not limited to identical median values but applies to most of the distribution of statures from at least the 25th to the 95th percentiles. Whatever complex of factors had been producing the secular trend to increasing body size of children (and adults) from the prenatal period onward had ceased to be of sufficient magnitude by 1955 or 1956 to affect these rather sensitive data across most socioeconomic levels of the American population. When the stragglers will finally achieve their genetic potential to full stature can probably be better predicted by economic and social factors than by biologic ones.

Mean stature or weight differences (in cm and kg) between HANES I and HES II or HES III, by sex: seven selected percentiles

Surveys compared	Percentile						
	5th	10th	25th	50th	75th	90th	95th
	Mean stature difference, male						
HANES I-HES II	0.31	0.66	-0.34	-0.16	0.14	0.05	0.15
HANES I-HES III	0.76	0.06	0.47	0.24	0.37	-0.02	0.33
	Mean stature difference, female						
HANES I-HES II	0.54	-0.05	-0.22	0.18	0.12	0.31	0.08
HANES I-HES III	0.79	0.45	-0.03	-0.51	-0.42	0.14	-0.16
	Mean weight difference, male						
HANES I-HES II	-0.13	0.10	0.02	0.17	0.51	0.37	1.09
HANES I-HES III	0.39	0.89	0.60	0.34	0.78	-0.86	0.43
	Mean weight difference, female						
HANES I-HES II	0.30	0.19	0.02	-0.13	-0.29	-0.31	-0.98
HANES I-HES III	-0.05	0.62	0.35	-0.19	0.24	1.47	4.51

REFERENCES

[1]Center for Disease Control: *Comparison of Body Weights and Lengths or Heights of Groups of Children.* Committee on Nutrition Advisory to CDC. Food and Nutrition Board. DHEW, Public Health Service, Mar. 1974.

[2]Owen, G. M.: The assessment and recording of measurements of growth of children: Report of a small conference. *Pediatrics* 51(3):461-466, Mar. 1973.

[3]Owen, G. M., et al.: A study of nutritional status of preschool children in the United States, 1968-70. *Pediatrics* 53(4), Part II, Supplement: 597-646, Apr. 1974.

[4]National Center for Health Statistics: Height and weight of children, United States. *Vital and Health Statistics.* Series 11-No. 104. DHEW Pub. No. (HRA) 75-1093. Health Resources Administration. Washington. U.S. Government Printing Office, Sept. 1970.

[5]National Center for Health Statistics: Height and weight of youths 12-17 years, United States. *Vital and Health Statistics.* Series 11-No. 124. DHEW Pub. No. (HSM) 73-1606. Health Services and Mental Health Administration. Washington. U.S. Government Printing Office, Jan. 1973.

[6]National Center for Health Statistics: Height and weight of children, socioeconomic status, United States. *Vital and Health Statistics.* Series 11-No. 119. DHEW Pub. No. (HSM) 73-1601. Health Services and Mental Health Administration. Washington. U.S. Government Printing Office, Oct. 1972.

[7]National Center for Health Statistics: Plan and initial program of the Health Examination Survey. *Vital and Health Statistics.* Series 1-No. 4. DHEW Pub. No. (HRA) 74-1038. Health Resources Administration. Washington. U.S. Government Printing Office, Nov. 1973.

[8]National Center for Health Statistics: Plan, operation, and response results of a program of children's examinations. *Vital and Health Statistics.* PHS Pub. No. 1000-Series 1-No. 5. Public Health Service. Washington. U.S. Government Printing Office, Oct. 1967.

[9]National Center for Health Statistics: Plan and operation of a Health Examination Survey of U.S. youths 12-17 years of age. *Vital and Health Statistics.* Series 1-No. 8. DHEW Pub. No. (HRA) 75-1018. Health Resources Administration. Washington. U.S. Government Printing Office, Sept. 1974.

[10]National Center for Health Statistics: Plan and operation of the Health and Nutrition Examination Survey, United States, 1971-73. *Vital and Health Statistics.* Series 1-No. 10a. DHEW Pub. No. (HSM) 73-1310. Health Services and Mental Health Administration. Washington. U.S. Government Printing Office, Feb. 1973.

[11]De Boor, C., and Rice, J. R.: *Least Squares Cubic Spline Approximation I-Fixed Knots.* Computer Science Dept., Purdue University, W. Lafayette, Ind. Technical Report No. 20, Apr. 1968.

[12]National Center for Health Statistics: NCHS Growth Charts, 1976. *Vital and Health Statistics.* Series 11. Health Resources Administration, DHEW, Rockville, Md. To be published.

[13]Shuttleworth, F. K.: Sexual maturation and the skeletal growth of girls age six to nineteen. *Monogr. Soc. Res. Child Dev.* 3(3), 1938.

[14]Damon, A.: Secular trend in height and weight within old American families at Harvard, 1870-1965. *Am. J. Phys. Anthropol.* 29(1):45-50, 1968.

[15]Damon, A.: Larger body size and earlier menarche: The end may be in sight. *Soc. Biol.* 21(1):8-11, 1974.

[16]Meredith, H. V.: Change in stature and body weight of North American boys during the last 80 years, in L. Lipsitt and C. Spiker, eds., *Advances in Child Development and Behavior,* Vol. 1. New York. Academic Press, 1963. pp. 69-114.

[17]Meredith, H. V.: Findings from Asia, Australia, Europe, and North America on secular change in mean height of children, youths and young adults. *Am. J. Phys. Anthropol.* 44(2):315-326, 1976.

[18]Meredith, H. V., and Meredith, E. M.: The stature of Toronto children half a century ago and today. *Hum. Biol.* 16:126-131, 1944.

[19]Tanner, J. M.: *Growth at Adolescence,* second ed. Oxford. Blackwell Scientific Pub., 1962.

[20]Tanner, J. M.: The secular trend towards earlier physical maturation. *Tijdschrift Voor Sociale Geneeskunde* 44:524-539, 1966.

[21]Tanner, J. M.: Earlier maturation in man. *Sci. Am.* 218(1):21-27, Jan. 1968.

[22]Tanner, J. M.: Trend toward earlier menarche in London, Oslo, Copenhagen, the Netherlands and Hungary. *Nature* 243:95-96, 1973.

[23]Maresh, M. M.: A forty-five year investigation for secular changes in physical maturation. *Am. J. Phys. Anthropol.* 36(1):103-109, Jan. 1972.

[24]Amundsen, D. W., and Diers, C. J.: The age of menarche in Classical Greece and Rome. *Hum. Biol.* 41(1):125-132, Feb. 1969.

[25]Krogman, W. M.: Growth of head, face, trunk, and limbs in Philadelphia white and Negro children of elementary and high school age. *Monogr. Soc. Res. Child Dev.* 35(3), Serial No. 136, 1970.

[26]Van Wieringen, J. C.: *Seculaire Groeiverschuiving: Lengte en Gewicht Surveys 1964-1966 in Netherlands in Historisch Perspectief.* Leiden. Netherlands Institute voor Praeventive Geneeskunde TNO, 1972.

[27]Boas, F.: Observations on growth of children. *Science* 72:44-48, 1930.

[28]Gruelich, W. W.: The adult body size of some American born Japanese whose height, weight, and skeletal age had also been recorded during childhood. *Am. J. Phys. Anthropol.* To be published.

[29]Kano, K., and Chung, C. S.: Do American born Japanese children still grow faster than native Japanese? *Am. J. Phys. Anthropol.* 43(2):187-194, Sept. 1975.

[30]Garn, S. M.: Magnitude of Secular Trend in the Fels Population. 1 p., lithoprinted, 1967.

[31]Bakwin, H., and McLaughlin, S. D.: Secular increase in height. Is the end in sight? *Lancet* 2:1195-1196, 1964.

GPO 906-196