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PERCENTILES OF MODERN HEIGHT STANDARDS FOR USE IN HISTORICAL RESEARCH

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ABSTRACT

Percentiles of modern height standards are useful in historical research because children differ systematically in height by age, and differences in growth potential exist by gender and might exist across some ethnic groups. Modern height standards are needed to make relative comparisons of nutritional status in these circumstances. The standards are also used to assess progress or deprivation against a level that we know is attainable under good environmental circumstances. Historical researchers in need of modern height standards encounter several problems, including the choice of standards, manipulation of those standards to meet the requirements of historical data, and calculation of percentiles. Following a discussion of criteria used in selecting standards, which lead to the choice of NCHS heights as a reference, the paper gives percentiles calculated in line with the requirements of historical data. Results are given in centimeters and inches and by age at last birthday and age at nearest birthday.

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The success of anthropometric history in the past two decades stems from several attributes, including abundance of evidence, comparability over long periods of time and across many geographic areas and ethnic groups, and a sense (gained from modern evidence on human growth) of the meaning of height differences in terms of functional significance or the quality of life. Given the evidence for widespread ethnic similarities in growth potential, investigators often compare heights directly to determine which groups or cohorts may have had net environmental advantages or disadvantages.

In some situations, however, direct comparisons of stature are inadequate or inappropriate. Children differ systematically in height by age, and differences in growth potential exist by gender. For example, it is fruitless to compare the heights of 8 year olds and 15 year olds, or of adult men and adult women to determine which group may have been better off. In these circumstances, relative comparisons should be made using percentiles attained on modern height standards. Standards are also essential for comparisons involving ethnic differences in growth potential. These reasons aside, the yardstick of modern height standards give a sense of perspective for any historical data. They provide a way of assessing progress or deprivation against a level that we know is attainable under good environmental circumstances.

Historical researchers in need of modern height standards encounter several problems, including the choice of standards, manipulation of those standards to meet the requirements of historical data, and calculation of percentiles. This paper addresses these concerns.

Choice of Standards

In recent decades scholars have conducted numerous height studies of well nourished populations.[1] The similarity of results for Europeans, those of European descent, Africans,

[1]See Eveleth and Tanner (1976; 1990) for discussion.

and those of African descent have given rise to what are loosely called "western" height standards. In a review of studies covering populations in Europe, New Guinea, and Mexico, L.A. Malcolm (1974) concludes that differences in average height between populations are almost entirely the product of the environment. Using data from well-nourished populations in several developed and developing countries, Martorell and Habicht (1986) report that children from Europe or European descent, Africa or African descent, and from India or the Middle East have similar growth profiles. Far-Eastern children or adults are an exception that may have a substantial genetic basis; well-off Japanese, for example, reach, on average, the fifteenth height percentile of the well-off in Britain (Tanner et al., 1982).[2] Important for interpreting stature in the United States is that Europeans and people of European descent, and Africans and people of African descent who grew under good nutritional circumstances have nearly identical stature (Eveleth and Tanner, 1976, Appendix).[3]

In principle, the results of any of the numerous twentieth-century height studies could be used as a "standard." I suppose that a well-conducted height study of Pygmies could serve the purpose. However, four useful criteria enter the picture. First, to insure widespread

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[2] Tanner bases his assessment on growth studies conducted in the 1970s, but recent data suggest that the height difference might be shrinking. The stature of adult American men increased by only 0.4 centimeters between birth cohorts of 1950 to 1970, while over the same period it rose by more than 3 centimeters among Japanese women who attended private school (Costa and Steckel, 1995; Takaishi and Kikuta, 1989). Of course, incomes grew very rapidly in post World War II Japan, and it remains to be seen whether the recent growth trend will continue.

[3] To the extent that genetic factors influence height, comparisons can be made by converting stature to percentiles of appropriate height standards.

applicability, auxologists (auxology is the study of human growth) prefer genetically diverse populations, which rules out the Pygmies. Because genetic differences in growth potential are small across most national populations, with exceptions noted above, many countries could fulfill this criterion. As the most diverse country, however, United States has an advantage in this category. Second, the population used as a standard should be well nourished because the results are often used to assess performance against the potential for growth. Americans, who are among the tallest in the world in the post WWII period, suit this purpose. Third, the results should be reliable. The National Center for Health Statistics (NCHS) data are based on very large samples and the measurements were conducted according to modern standards of auxology (National Center for Health Statistics, 1977, pp. 4-5). Fourth, many investigators should agree to use the standards. Height standards become a type of currency into which diverse populations are converted or compared. In the same way that the US dollar has become a widely used measure of value in international trade, American height standards are a type of auxological currency used in international health comparisons. By using the same reference population, investigators avoid confusion over what is meant by "percentiles attained on modern height standards." Without this agreement or common usage, the same stature could refer to different percentiles. Among the "western" standards available, the NCHS (National Center for Health Statistics, 1977) are the most widely used. The World Health Organization has adopted these standards for international anthropometric reference and they are widely cited in the economic development and health literature (Carlson and Wardlaw, 1990). For these various reasons, I recommend using NCHS standards in historical research, assuming that "western" standards are the appropriate bench mark for comparison. Researchers who are uncertain about the growth potential of their population under study are advised to investigate the matter or consult experts in anthropometrics.

The NCHS growth curves used here are based on nationally representative samples of American children who were measured in the 1960s or 1970s (National Center for Health

Statistics, 1977, p. 3). Data from three separate surveys were pooled to obtain the standards: HES Cycle II of children ages 6-11 years (1963-65), HES Cycle III of youths aged 12-17 years (1966-70), and HANES I of children aged 1-17 years (1971-74). Similarity in sample designs permitted researchers to meld the data for consecutive age groups or combine them when age groups overlapped.

Requirements of Historical Research

The NCHS percentiles are presented in half year increments for exact ages from 2.0 years to 18.0 years and the stature in centimeters is given for smoothed percentiles of 5, 10, 25, 50, 75, 90, and 95.[4] Though helpful, in many ways these data are inadequate for historical research. First, the range of percentiles is too narrow for historical applications in which there was extensive deprivation. For example, study of American slave children or German peasants requires percentiles below the 5th (Steckel, 1986; Komlos, 1990). Second, historical researchers often want exact percentiles to make precise comparisons over time or across space. The widely dispersed percentiles that are published give some useful indications but linear interpolation that is often required leads to distortions that simply does not meet needs of historians. Third, because the standard deviations of the distributions are not published, one cannot readily calculate the exact percentiles under the assumption of normality of the height distributions.

A second dimension of problems arises from the way that historical evidence was recorded. In particular, age was usually rounded, often given as of last birthday. This situation poses no difficulties for adults, but age aggregation among children who are growing creates a need for a modified set of percentiles. Nearly a century ago, Boas identified this problem and proposed a correction, and the matter has been taken up systematically by M.J.R.

[4] The percentiles were smoothed by fitting a cubic spline approximation to the raw data.

Healy (1962). Specifically, the adjustment requires that the variances of the height distributions at exact ages be augmented by a term that captures the greater dispersion imposed by aggregating growing children into age categories.

Calculating Percentiles

Using cubic spline functions, the NCHS smoothed the raw height distributions at each exact age to obtain percentiles. The NCHS did not impose a condition of normality to estimate their percentiles, but here I use the knowledge that heights of well nourished populations usually take the shape of a normal distribution to estimate the standard deviations of the height distributions and to calculate percentiles. Below I discuss the implications of a very modest exception to normality that occurs during adolescence.

I estimated the standard deviations of the height distributions at exact ages by using the heights published for the 10th and the 90th percentiles. With knowledge that the 10th and 90th percentiles are 1.282 standard deviations from the mean, I converted the difference in height between these percentiles and the mean (50th percentile) into an estimate of the standard deviation of the distribution.[5]

Then I applied the relationship devised by Healy (1962) to allow for the greater variance of height distributions that accrues from bunching heights of growing children measured at somewhat different exact ages, as in age at last birthday. The variance of such a

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[5]Specifically, I took the difference in stature between the 90th and 10th percentiles and divided by 2 times 1.282. Among boys aged 12.5, for example, heights at the 10th and 90th percentiles are 143.0 and 163.2 cm, respectively. Then s.d. = (163.2 - 143.0)/(2 x 1.282) = 7.88 cm.

distribution exceeds that for a distribution of heights at an exact age because the children differ in the exact amount of time for growth since birth.

Healy has shown that the variance of the pooled distribution, κ_2, and the variance of stature at a central exact age, c, are connected as follows:

$$\kappa_2 = c + (b^2)/12$$

where b is the height increment between the exact ages that form the end points of the age group. I estimate c using the standard deviations calculated from the NCHS percentiles, while b is estimated by the average height increment over the period in question. The variances differ by the adjustment term $(b^2)/12$, which implies that the higher the growth rate and the smaller the variance at a central exact age, the more important is the adjustment to the variance. Although the precise mathematical form of the adjustment term is derived from a moment generating function, it makes intuitive sense that it is directly related to the growth rate. The dispersion of heights within an age group of growing children depends upon three factors: genetic potential for growth, environmental circumstances since conception, and growth within the age range of the category. The first two factors are captured by c while the adjustment term incorporates the third factor.[6] Children at the upper end of the age range are taller than those at the bottom end of the range by an amount that reflects their differences in stature due to growth over the time interval corresponding to the age category.

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[6] This categorization of factors influencing growth, though somewhat simplistic, helps to convey an intuitive understanding of the variance formula. In reality there may be interaction between genetic factors and environmental conditions, changing environmental conditions may affect growth within the age category, the height of a child may depend upon the health of the mother prior to conception, etc. See Eveleth and Tanner (1976; 1990) and references therein.

Though relevant, the variance adjustment is modest among older children. For example, among adolescent boys aged 12.5 the height increment (value of *b*) between ages 12.0 and 13.0 is 6.8 cm, and the variance in stature at the central age of 12.5 (value of *c*) is 7.88 x 7.88 = 62.09, which implies that the adjustment term is (6.8 x 6.8)/12 = 3.85 out of an adjusted variance of 62.09 + 3.85 = 65.94, or 5.8 per cent. The adjustment is most important at young ages, where the unadjusted variances are small and the height increments are large. Among boys aged 3.5, for example, the adjustment equals 24 percent of the adjusted variance. Obviously, the adjustment term equals zero for adults who are no longer growing.

Imposing normality on the NCHS height distributions creates a slight distortion, which is greatest during adolescence because children may differ by a few years in the age at which their adolescent growth spurt begins. Early adolescence is marked by the appearance of some children who are precocious in their growth. These early maturers skew the height distribution to the right. Similarly, "late bloomers" skew the height distribution to the left in late adolescence.

The consequences of assuming normality are worth noting, but they are relatively unimportant for most historical research. Table 1 compares percentiles of stature by method for boys in early (11.5 years) and late (15.5 years) adolescence. For example, in early adolescence, stature at the 95th NCHS percentile is 158.5 cm compared with 157.9 cm as tabulated under the assumption of normality. In late adolescence, height at the 5th NCHS percentile is 158.3 cm compared with 158.9 cm under the assumption of normality. The magnitudes of these differences are small compared with those that may arise from sampling error, sample selectivity, rounding error, or composition effects in raw historical data. Measurement problems aside, the differences by method reported in Table 1 nowhere exceed 0.6 centimeters, which is probably below the threshold of practical significance in stature research, i.e. it is doubtful that stature differences as small as 0.6 cm, even if accurately measured, reflect contrasts in environmental conditions of historical importance. Moreover, it

is worth keeping in mind that the NCHS results, though tabulated from samples in the hundreds of thousands at each age, are subject to minor sampling errors, particularly in the tails of the distributions.

In view of the small differences by method, I present the results below as approximate percentiles of modern height standards. If important for historical research, it would be possible to calculate more exact results by returning to the NCHS sample and tabulating the appropriate smoothed percentiles from the raw data aggregated by age at last birthday or by age at nearest birthday.

The tables end at age 18, which may appear to create a difficulty for study of historical populations that can grow into their early twenties. Because terminal adult height is reached by age 18 in modern well-nourished populations, however, the appropriate comparison for older adults in historical populations is with the modern standard at age 18. An exception to this advice concerns adults who shrink at more advanced ages. As adults grow older, vertebrae and other joints may compress such that individuals lose stature. In view of this, most investigators (especially, if blessed with an abundance of data) simply discard those observations over age 49. Many sources, such as military records, have relatively few individuals in the older age categories anyway. On the other hand, if data are scarce or if older individuals are needed to estimate stature among early birth cohorts, researchers can apply formulas that correct for shrinkage.[7]

Results

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[7] Shrinkage begins around the mid twenties and accelerates beyond age 45. Between ages 50 and 70 males lose on average about 2.7 cm of stature while females lose about 3.1 cm. See Chandler and Bock (1991).

Table 2 sets forth the modern height standards, unadjusted standard deviations, height increments, and adjusted standard deviations in centimeters for males whose ages are given at last birthday. Note that the exact ages are centered at half years (2.5, 3.5, etc.), the mean ages of those listed at last birthday. Because children who were age x at last birthday varied in age from exactly x to just under x + 1, they were, on average, approximately age x + 0.5. Column 3 of Table 2 presents the unadjusted standard deviations at the central ages (x + 0.5) as calculated from the NCHS tables under the assumption of normality. These quantities are the square roots of c in the Healy formula. Values of b (in the Healy formula) are given in column 4. Note that these height increments are determined by subtracting average height at exact age x from average height at exact age x + 1, values which are not shown in the table.[8] The last column gives the standard deviations adjusted according to the Healy formula. At age 12.5, for example, the adjusted standard deviation is calculated as follows:

$$8.12 = \sqrt{(7.88)^2 + (6.80)^2 / 12}\,.$$

The means given in column 2 and the standard deviations given in the last column of the table can be used (under the assumption of normality) to calculate exact percentiles by converting differences between the standards and the historical heights into z scores. Table 3 presents the corresponding modern height standards and adjusted standard deviations for females.

Because an intuitive notion of the height percentiles is useful, and under some circumstances it may be inconvenient to calculate exact percentiles, I present the heights for detailed percentiles in Tables 4 and 5. The percentiles range from 0.1 to 50, with the upper bound chosen by knowledge that few historical populations exceeded modern height standards

[8] The relevant heights are given in Tables 6-7 on age at last birthday. See below.

(50th percentile). Since the distribution is symmetric, however, percentiles for the upper part of the distribution can easily be calculated from the information given.

Although historical ages were frequently given at last birthday, on the chance that some may have been recorded at nearest birthday, I use Tables 6-9 to present information similar to Tables 2-5, except that calculations refer to age at nearest birthday. In these tables the exact ages range from x - 0.5 to x + 0.5 and the age groups are centered at exact age x.

The metric system is widely used in international anthropometric research, but many historical sources reported heights in inches and some studies express their results in these units of measurement. For these reasons I also include modern percentiles of stature in inches. Tables 10-17 follow the format of Tables 2-9 except that heights are given in inches.

Concluding Remarks

The percentiles of stature given in this paper are appropriate for situations in which "western" height standards adequately represent growth potential. Similar tables could be developed for populations in which other standards are suitable, and the results would facilitate comparisons across genetically diverse groups.

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Table 1: Percentiles of Stature in Centimeters by Method, Boys Aged 11.5 or 15.5

		Percentile						
Age	Method	5	10	25	50	75	90	95
11.5	(a) NCHS	135.0	137.7	141.5	146.4	151.1	155.6	158.5
	(b) Normal	134.9	137.5	141.7	146.4	151.1	155.3	157.9
	(b) - (a)	-0.1	-0.2	0.2	0.0	0.0	-0.3	-0.4
15.5	(a) NCHS	158.3	161.2	166.2	171.5	176.3	180.8	183.9
	(b) Normal	158.9	161.7	166.3	171.5	176.7	181.3	184.1
	(b) - (a)	0.6	0.5	0.1	0.0	0.4	0.5	0.2

Source: Calculated from National Center for Health Statistics (1977, Table 13, p. 37).

Table 2: Modern Height Standards and Standard Deviations in Centimeters, Males at Last Birthday

Exact Age	Modern Height Standard	Unadjusted s.d.	Height Increment	Adjusted s.d.
2.5	90.4	3.55	8.10	4.25
3.5	99.1	4.06	8.00	4.67
4.5	106.6	4.41	7.00	4.85
5.5	113.1	4.68	6.20	5.01
6.5	119.0	4.91	5.60	5.17
7.5	124.4	5.15	5.30	5.37
8.5	129.6	5.38	5.20	5.59
9.5	134.8	5.77	5.30	5.97
10.5	140.3	6.28	5.80	6.50
11.5	146.4	6.98	6.40	7.22
12.5	153.0	7.88	6.80	8.12
13.5	159.9	8.50	6.60	8.71
14.5	166.2	8.42	5.90	8.59
15.5	171.5	7.64	4.50	7.75
16.5	175.2	6.83	2.70	6.87
17.5	176.7	6.44	0.60	6.44
18.0	176.8	6.47	0.00	6.47

Source: Calculated from National Center for Health Statistics (1977, Table 13, p. 37).

Table 3: Modern Height Standards and Standard Deviations in Centimeters, Females at Last Birthday

Exact Age	Modern Height Standard	Unadjusted s.d.	Height Increment	Adjusted s.d.
2.5	90.0	3.78	7.30	4.33
3.5	97.9	3.82	7.50	4.39
4.5	105.0	4.10	6.80	4.54
5.5	111.6	4.60	6.20	4.94
6.5	117.6	5.15	6.00	5.43
7.5	123.5	5.73	5.80	5.97
8.5	129.3	6.28	5.80	6.50
9.5	135.2	6.75	6.10	6.97
10.5	141.5	6.98	6.50	7.23
11.5	148.2	6.98	6.70	7.24
12.5	154.6	6.83	5.60	7.01
13.5	159.0	6.75	3.30	6.81
14.5	161.2	6.75	1.40	6.76
15.5	162.1	6.75	0.60	6.75
16.5	162.7	6.47	0.70	6.48
17.5	163.4	6.05	0.60	6.05
18.0	163.7	5.85	0.00	5.85

Source: Calculated from National Center for Health Statistics (1977, Table 13, p. 37).

Table 4: Modern Stature in Centimeters at Various Percentiles, Males at Last Birthday

Age at Last Birthday	Percentile													
	0.1	0.5	1	2.5	5	10	15	20	25	30	35	40	45	50
2	77.3	79.5	80.5	82.1	83.4	85.0	86.0	86.8	87.5	88.2	88.8	89.3	89.9	90.4
3	84.7	87.1	88.2	90.0	91.4	93.1	94.3	95.2	96.0	96.7	97.3	97.9	98.5	99.1
4	91.6	94.1	95.3	97.1	98.6	100.4	101.6	102.5	103.3	104.1	104.7	105.4	106.0	106.6
5	97.6	100.2	101.4	103.3	104.8	106.7	107.9	108.9	109.7	110.5	111.2	111.8	112.5	113.1
6	103.0	105.7	107.0	108.9	110.4	112.4	113.6	114.6	115.5	116.3	117.0	117.7	118.3	119.0
7	107.8	110.6	111.9	113.9	115.5	117.5	118.8	119.9	120.8	121.6	122.3	123.0	123.7	124.4
8	112.3	115.2	116.6	118.6	120.4	122.4	123.8	124.9	125.8	126.7	127.4	128.2	128.9	129.6
9	116.3	119.4	120.9	123.1	124.9	127.1	128.6	129.8	130.8	131.7	132.5	133.3	134.0	134.8
10	120.2	123.6	125.2	127.6	129.6	132.0	133.6	134.8	135.9	136.9	137.8	138.7	139.5	140.3
11	124.1	127.8	129.6	132.2	134.5	137.1	138.9	140.3	141.5	142.6	143.6	144.6	145.5	146.4
12	127.9	132.1	134.1	137.1	139.6	142.6	144.6	146.2	147.5	148.7	149.9	150.9	152.0	153.0
13	133.0	137.5	139.6	142.8	145.5	148.7	150.9	152.6	154.0	155.3	156.5	157.7	158.8	159.9
14	139.6	144.1	146.2	149.4	152.0	155.2	157.3	159.0	160.4	161.7	162.9	164.0	165.1	166.2
15	147.5	151.5	153.5	156.3	158.7	161.6	163.5	165.0	166.3	167.4	168.5	169.5	170.5	171.5
16	154.9	157.5	159.2	161.7	163.8	166.4	168.1	169.4	170.6	171.6	172.6	173.5	174.3	175.2
17	156.8	160.1	161.7	164.1	166.1	168.4	170.0	171.3	172.4	173.3	174.2	175.1	175.9	176.7
18	156.8	160.1	161.7	164.1	166.1	168.5	170.1	171.3	172.4	173.4	174.3	175.2	176.0	176.8

Source: Calculated from National Center for Health Statistics (1977, Table 13, p. 37).

Table 5: Modern Stature in Centimeters at Various Percentiles, Females at Last Birthday

Age at Last Birthday	Percentile													
	0.1	0.5	1	2.5	5	10	15	20	25	30	35	40	45	50
2	76.6	78.8	79.9	81.5	82.8	84.4	85.5	86.4	87.1	87.7	88.3	88.9	89.5	90.0
3	84.3	86.6	87.7	89.3	90.6	92.3	93.3	94.2	94.9	95.6	96.2	96.8	97.3	97.9
4	91.0	93.3	94.4	96.1	97.5	99.2	100.3	101.2	101.9	102.6	103.3	103.9	104.4	105.0
5	96.3	98.9	100.1	101.9	103.4	105.3	106.5	107.4	108.3	109.0	109.7	110.4	111.0	111.6
6	100.8	103.6	105.0	107.0	108.6	110.6	112.0	113.0	113.9	114.8	115.5	116.2	116.9	117.6
7	105.0	108.1	109.6	111.8	113.6	115.8	117.3	118.5	119.5	120.4	121.2	122.0	122.7	123.5
8	109.2	112.6	114.2	116.6	118.6	121.0	122.6	123.8	124.9	125.9	126.8	127.7	128.5	129.3
9	113.7	117.2	119.0	121.5	123.7	126.3	128.0	129.3	130.5	131.5	132.5	133.4	134.3	135.2
10	119.2	122.9	124.7	127.3	129.5	132.2	134.0	135.4	136.6	137.7	138.7	139.7	140.6	141.5
11	125.8	129.5	131.3	134.0	136.2	138.9	140.7	142.1	143.3	144.4	145.4	146.4	147.3	148.2
12	132.9	136.5	138.3	140.9	143.0	145.6	147.3	148.7	149.9	150.9	151.9	152.8	153.7	154.6
13	137.9	141.4	143.2	145.6	147.7	150.3	151.9	153.3	154.4	155.4	156.4	157.3	158.1	159.0
14	140.3	143.8	145.5	148.0	150.0	152.5	154.2	155.5	156.6	157.7	158.6	159.5	160.3	161.2
15	141.2	144.7	146.4	148.9	150.9	153.4	155.1	156.4	157.6	158.6	159.5	160.4	161.2	162.1
16	142.7	146.0	147.6	150.0	152.0	154.4	156.0	157.2	158.3	159.3	160.2	161.1	161.9	162.7
17	144.7	147.8	149.3	151.5	153.4	155.6	157.1	158.3	159.3	160.2	161.1	161.9	162.6	163.4
18	145.6	148.6	150.1	152.2	154.0	156.2	157.6	158.8	159.8	160.6	161.4	162.2	163.0	163.7

Source: Calculated from National Center for Health Statistics (1977, Table 13, p. 37).

Table 6: Modern Height Standards and Standard Deviations in Centimeters, Males at Nearest Birthday

Exact Age	Modern Height Standard	Unadjusted s.d.	Height Increment	Adjusted s.d.
3.0	94.9	3.82	8.70	4.57
4.0	102.9	4.25	7.50	4.77
5.0	109.9	4.56	6.50	4.93
6.0	116.1	4.80	5.90	5.09
7.0	121.7	5.03	5.40	5.27
8.0	127.0	5.23	5.20	5.44
9.0	132.2	5.54	5.20	5.74
10.0	137.5	6.01	5.50	6.21
11.0	143.3	6.63	6.10	6.86
12.0	149.7	7.45	6.60	7.69
13.0	156.5	8.27	6.90	8.50
14.0	163.1	8.58	6.30	8.77
15.0	169.0	8.07	5.30	8.22
16.0	173.5	7.22	3.70	7.29
17.0	176.2	6.51	1.50	6.53
18.0	176.8	6.47	0.00	6.47

Source: Calculated from National Center for Health Statistics (1977, Table 13, p. 37).

Table 7: Modern Height Standards and Standard Deviations in Centimeters, Females at Nearest Birthday

Exact Age	Modern Height Standard	Unadjusted s.d.	Height increment	Adjusted s.d.
3.0	94.1	3.78	7.90	4.42
4.0	101.6	3.98	7.10	4.48
5.0	108.4	4.33	6.60	4.73
6.0	114.6	4.84	6.00	5.14
7.0	120.6	5.46	5.90	5.72
8.0	126.4	6.05	5.80	6.27
9.0	132.2	6.55	5.90	6.77
10.0	138.3	6.90	6.30	7.14
11.0	144.8	7.06	6.70	7.32
12.0	151.5	6.90	6.40	7.15
13.0	157.1	6.75	4.40	6.87
14.0	160.4	6.71	2.20	6.74
15.0	161.8	6.75	0.90	6.75
16.0	162.4	6.63	0.60	6.63
17.0	163.1	6.28	0.70	6.28
18.0	163.7	5.85	0.00	5.85

Source: Calculated from National Center for Health Statistics (1977, Table 13, p. 37).

Table 8: Modern Stature in Centimeters at Various Percentiles, Males at Nearest Birthday

Age at Nearest Birthday	Percentiles													
	0.1	0.5	1	2.5	5	10	15	20	25	30	35	40	45	50
3.0	80.8	83.1	84.3	85.9	87.3	89.0	90.2	91.0	91.8	92.5	93.1	93.7	94.3	94.9
4.0	88.2	90.6	91.8	93.5	95.0	96.8	98.0	98.9	99.7	100.4	101.1	101.7	102.3	102.9
5.0	94.7	97.2	98.4	100.2	101.7	103.6	104.8	105.7	106.6	107.3	108.0	108.7	109.3	109.9
6.0	100.4	103.0	104.3	106.1	107.7	109.6	110.8	111.8	112.7	113.4	114.1	114.8	115.5	116.1
7.0	105.4	108.1	109.4	111.4	113.0	114.9	116.2	117.3	118.1	118.9	119.7	120.4	121.0	121.7
8.0	110.2	113.0	114.4	116.3	118.0	120.0	121.4	122.4	123.3	124.2	124.9	125.6	126.3	127.0
9.0	114.5	117.4	118.9	121.0	122.7	124.8	126. 3	127.4	128.3	129.2	130.0	130.7	131.5	132.2
10.0	118.3	121.5	123.0	125.3	127.2	129.5	131.1	132.3	133.3	134.2	135.1	135.9	136.7	137.5
11.0	122.1	125.6	127.3	129.9	132.0	134.5	136.2	137.5	138.7	139.7	140.7	141.6	142.4	143.3
12.0	125.9	129.9	131.8	134.6	137.0	139.8	141.7	143.2	144.5	145.7	146.7	147.8	148.7	149.7
13.0	130.2	134.6	136.7	139.8	142.4	145.6	147.7	149.3	150.8	152.0	153.2	154.3	155.4	156.5
14.0	136.0	140.5	142.7	145.9	148.6	151.9	154.0	155.7	157.2	158.5	159.7	160.9	162.0	163.1
15.0	143.6	147.8	149.9	152.9	155.4	158.5	160.5	162.1	163.5	164.7	165.8	166.9	168.0	169.0
16.0	151.0	154.7	156.5	159.2	161.4	164.1	165.9	167.4	168.6	169.7	170.7	171.7	172.6	173.5
17.0	156.0	159.4	161.0	163.4	165.4	167.8	169.4	170.7	171.8	172.8	173.7	174.5	175.4	176.2
18.0	156.8	160.1	161.7	164.1	166.1	168.5	170.1	171.3	172.4	173.4	174.3	175.2	176.0	176.8

Source: Calculated from National Center for Health Statistics (1977, Table 13, p. 37).

Table 9: Modern Stature in Centimeters at Various Percentiles, Females at Nearest Birthday

Age at Nearest Birthday	Percentile													
	0.1	0.5	1	2.5	5	10	15	20	25	30	35	40	45	50
3.0	80.5	82.7	83.8	85.4	86.8	88.4	89.5	90.4	91.1	91.8	92.4	93.0	93.5	94.1
4.0	87.8	90.1	91.2	92.8	94.2	95.9	97.0	97.8	98.6	99.3	99.9	100.5	101.0	101.6
5.0	93.8	96.2	97.4	99.1	100.6	102.3	103.5	104.4	105.2	105.9	106.6	107.2	107.8	108.4
6.0	98.7	101.4	102.7	104.5	106.1	108.0	109.3	110.3	111.1	111.9	112.6	113.3	114.0	114.6
7.0	102.9	105.9	107.3	109.4	111.1	113.3	114.7	115.8	116.7	117.6	118.4	119.2	119.9	120.6
8.0	107.0	110.2	111.8	114.1	116.0	118.4	119.9	121.1	122.2	123.1	124.0	124.8	125.6	126.4
9.0	111.3	114.8	116.5	118.9	121.0	123.5	125.2	126.5	127.6	128.7	129.6	130.5	131.3	132.2
10.0	116.2	119.9	121.7	124.3	126.5	129.1	130.9	132.3	133.5	134.6	135.6	136.5	137.4	138.3
11.0	122.2	125.9	127.8	130.5	132.7	135.4	137.2	138.6	139.9	141.0	142.0	142.9	143.9	144.8
12.0	129.4	133.1	134.9	137.5	139.7	142.3	144.1	145.5	146.7	147.8	148.7	149.7	150.6	151.5
13.0	135.9	139.4	141.1	143.6	145.7	148.3	150.0	151.3	152.5	153.5	154.5	155.4	156.2	157.1
14.0	139.6	143.0	144.7	147.2	149.3	151.8	153.4	154.7	155.9	156.9	157.8	158.7	159.6	160.4
15.0	140.9	144.4	146.1	148.6	150.6	153.1	154.8	156.1	157.2	158.3	159.2	160.1	160.9	161.8
16.0	141.9	145.3	147.0	149.4	151.4	153.9	155.5	156.8	157.9	158.9	159.8	160.7	161.6	162.4
17.0	143.7	146.9	148.5	150.8	152.7	155.0	156.6	157.8	158.9	159.8	160.7	161.5	162.3	163.1
18.0	145.6	148.6	150.1	152.2	154.0	156.2	157.6	158.8	159.8	160.6	161.4	162.2	163.0	163.7

Source: Calculated from National Center for Health Statistics (1977, Table 13, p. 37).

Table 10: Modern Height Standards and Standard Deviations in Inches, Males at Last Birthday

Exact Age	Modern Height Standard	Unadjusted s.d.	Height Increment	Adjusted s.d.
2.5	35.59	1.40	3.19	1.67
3.5	39.02	1.60	3.15	1.84
4.5	41.97	1.74	2.76	1.91
5.5	44.53	1.84	2.44	1.97
6.5	46.85	1.93	2.20	2.04
7.5	48.98	2.03	2.09	2.11
8.5	51.02	2.12	2.05	2.20
9.5	53.07	2.27	2.09	2.35
10.5	55.24	2.47	2.28	2.56
11.5	57.64	2.75	2.52	2.84
12.5	60.24	3.10	2.68	3.20
13.5	62.95	3.35	2.60	3.43
14.5	65.43	3.31	2.32	3.38
15.5	67.52	3.01	1.77	3.05
16.5	68.98	2.69	1.06	2.70
17.5	69.57	2.54	0.24	2.54
18.0	69.61	2.55	0.00	2.55

Source: Calculated from National Center for Health Statistics (1977, Table 13, p. 37).

Table 11: Modern Height Standards and Standard Deviations in Inches, Females at Last Birthday

Exact Age	Modern Height Standard	Unadjusted s.d.	Height Increment	Adjusted s.d.
2.5	35.43	1.49	2.87	1.70
3.5	38.54	1.50	2.95	1.73
4.5	41.34	1.61	2.68	1.79
5.5	43.94	1.81	2.44	1.94
6.5	46.30	2.03	2.36	2.14
7.5	48.62	2.26	2.28	2.35
8.5	50.91	2.47	2.28	2.56
9.5	53.23	2.66	2.40	2.74
10.5	55.71	2.75	2.56	2.85
11.5	58.35	2.75	2.64	2.85
12.5	60.87	2.69	2.20	2.76
13.5	62.60	2.66	1.30	2.68
14.5	63.46	2.66	0.55	2.66
15.5	63.82	2.66	0.24	2.66
16.5	64.06	2.55	0.28	2.55
17.5	64.33	2.38	0.24	2.38
18.0	64.45	2.30	0.00	2.30

Source: Calculated from National Center for Health Statistics (1977, Table 13, p. 37).

Table 12: Modern Stature in Inches at Various Percentiles, Males at Last Birthday

Age at Last Birthday	Percentile													
	0.1	0.5	1.0	2.5	5	10	15	20	25	30	35	40	45	50
2	30.43	31.30	31.69	32.32	32.83	33.46	33.86	34.17	34.45	34.72	34.96	35.16	35.39	35.59
3	33.35	34.29	34.72	35.43	35.98	36.65	37.13	37.48	37.80	38.07	38.31	38.54	38.78	39.02
4	36.06	37.05	37.52	38.23	38.82	39.53	40.00	40.35	40.67	40.98	41.22	41.50	41.73	41.97
5	38.43	39.45	39.92	40.67	41.26	42.01	42.48	42.87	43.19	43.50	43.78	44.02	44.29	44.53
6	40.55	41.61	42.13	42.87	43.46	44.25	44.72	45.12	45.47	45.79	46.06	46.34	46.57	46.85
7	42.44	43.54	44.06	44.84	45.47	46.26	46.77	47.20	47.56	47.87	48.15	48.43	48.70	48.98
8	44.21	45.35	45.91	46.69	47.40	48.19	48.74	49.17	49.53	49.88	50.16	50.47	50.75	51.02
9	45.79	47.01	47.60	48.46	49.17	50.04	50.63	51.10	51.50	51.85	52.17	52.48	52.76	53.07
10	47.32	48.66	49.29	50.24	51.02	51.97	52.60	53.07	53.50	53.90	54.25	54.61	54.92	55.24
11	48.86	50.31	51.02	52.05	52.95	53.98	54.69	55.24	55.71	56.14	56.54	56.93	57.28	57.64
12	50.35	52.01	52.80	53.98	54.96	56.14	56.93	57.56	58.07	58.54	59.02	59.41	59.84	60.24
13	52.36	54.13	54.96	56.22	57.28	58.54	59.41	60.08	60.63	61.14	61.61	62.09	62.52	62.95
14	54.96	56.73	57.56	58.82	59.84	61.10	61.93	62.60	63.15	63.66	64.13	64.57	65.00	65.43
15	58.07	59.65	60.43	61.54	62.48	63.62	64.37	64.96	65.47	65.91	66.34	66.73	67.13	67.52
16	60.98	62.01	62.68	63.66	64.49	65.51	66.18	66.69	67.17	67.56	67.95	68.31	68.62	68.98
17	61.73	63.03	63.66	64.61	65.39	66.30	66.93	67.44	67.87	68.23	68.58	68.94	69.25	69.57
18	61.73	63.03	63.66	64.61	65.39	66.34	66.97	67.44	67.87	68.27	68.62	68.98	69.29	69.61

Source: Calculated from National Center for Health Statistics (1977, Table 13, p. 37).

Table 13: Modern Stature in Inches at Various Percentiles, Females at Last Birthday

Age at Last Birthday	Percentile													
	0.1	0.5	1.0	2.5	5	10	15	20	25	30	35	40	45	50
2	30.16	31.02	31.46	32.09	32.60	33.23	33.66	34.02	34.29	34.53	34.76	35.00	35.24	35.43
3	33.19	34.09	34.53	35.16	35.67	36.34	36.73	37.09	37.36	37.64	37.87	38.11	38.31	38.54
4	35.83	36.73	37.17	37.83	38.39	39.06	39.49	39.84	40.12	40.39	40.67	40.91	41.10	41.34
5	37.91	38.94	39.41	40.12	40.71	41.46	41.93	42.28	42.64	42.91	43.19	43.46	43.70	43.94
6	39.69	40.79	41.34	42.13	42.76	43.54	44.09	44.49	44.84	45.20	45.47	45.75	46.02	46.30
7	41.34	42.56	43.15	44.02	44.72	45.59	46.18	46.65	47.05	47.40	47.72	48.03	48.31	48.62
8	42.99	44.33	44.96	45.91	46.69	47.64	48.27	48.74	49.17	49.57	49.92	50.28	50.59	50.91
9	44.76	46.14	46.85	47.83	48.70	49.72	50.39	50.91	51.38	51.77	52.17	52.52	52.87	53.23
10	46.93	48.39	49.09	50.12	50.98	52.05	52.76	53.31	53.78	54.21	54.61	55.00	55.35	55.71
11	49.53	50.98	51.69	52.76	53.62	54.69	55.39	55.94	56.42	56.85	57.24	57.64	57.99	58.35
12	52.32	53.74	54.45	55.47	56.30	57.32	57.99	58.54	59.02	59.41	59.80	60.16	60.51	60.87
13	54.29	55.67	56.38	57.32	58.15	59.17	59.80	60.35	60.79	61.18	61.57	61.93	62.24	62.60
14	55.24	56.61	57.28	58.27	59.06	60.04	60.71	61.22	61.65	62.09	62.44	62.80	63.11	63.46
15	55.59	56.97	57.64	58.62	59.41	60.39	61.06	61.57	62.05	62.44	62.80	63.15	63.46	63.82
16	56.18	57.48	58.11	59.06	59.84	60.79	61.42	61.89	62.32	62.72	63.07	63.43	63.74	64.06
17	56.97	58.19	58.78	59.65	60.39	61.26	61.85	62.32	62.72	63.07	63.43	63.74	64.02	64.33
18	57.32	58.50	59.09	59.92	60.63	61.50	62.05	62.52	62.91	63.23	63.54	63.86	64.17	64.45

Source: Calculated from National Center for Health Statistics (1977, Table 13, p. 37).

Table 14: Modern Height Standards and Standard Deviations in Inches, Males at Nearest Birthday

Exact Age	Modern Height Standard	Unadjusted s.d.	Height Increment	Adjusted s.d.
3.0	37.36	1.50	3.43	1.80
4.0	40.51	1.67	2.95	1.88
5.0	43.27	1.80	2.56	1.94
6.0	45.71	1.89	2.32	2.00
7.0	47.91	1.98	2.13	2.07
8.0	50.00	2.06	2.05	2.14
9.0	52.05	2.18	2.05	2.26
10.0	54.13	2.37	2.17	2.44
11.0	56.42	2.61	2.40	2.70
12.0	58.94	2.93	2.60	3.03
13.0	61.61	3.26	2.72	3.35
14.0	64.21	3.38	2.48	3.45
15.0	66.54	3.18	2.09	3.24
16.0	68.31	2.84	1.46	2.87
17.0	69.37	2.56	0.59	2.57
18.0	69.61	2.55	0.00	2.55

Source: Calculated from National Center for Health Statistics (1977, Table 13, p. 37).

Table 15: Modern Height Standards and Standard Deviations in Inches, Females at Nearest Birthday

Exact Age	Modern Height Standard	Unadjusted s.d.	Height increment	Adjusted s.d.
3.0	37.05	1.49	3.11	1.74
4.0	40.00	1.57	2.80	1.76
5.0	42.68	1.70	2.60	1.86
6.0	45.12	1.91	2.36	2.02
7.0	47.48	2.15	2.32	2.25
8.0	49.76	2.38	2.28	2.47
9.0	52.05	2.58	2.32	2.67
10.0	54.45	2.72	2.48	2.81
11.0	57.01	2.78	2.64	2.88
12.0	59.65	2.72	2.52	2.81
13.0	61.85	2.66	1.73	2.70
14.0	63.15	2.64	0.87	2.65
15.0	63.70	2.66	0.35	2.66
16.0	63.94	2.61	0.24	2.61
17.0	64.21	2.47	0.28	2.47
18.0	64.45	2.30	0.00	2.30

Source: Calculated from National Center for Health Statistics (1977, Table 13, p. 37).

Table 16: Modern Stature in Inches at Various Percentiles, Males at Nearest Birthday

Age at Nearest Birthday	Percentile													
	0.1	0.5	1.0	2.5	5	10	15	20	25	30	35	40	45	50
3.0	31.81	32.72	33.19	33.82	34.37	35.04	35.51	35.83	36.14	36.42	36.65	36.89	37.13	37.36
4.0	34.72	35.67	36.14	36.81	37.40	38.11	38.58	38.94	39.25	39.53	39.80	40.04	40.28	40.51
5.0	37.28	38.27	38.74	39.45	40.04	40.79	41.26	41.61	41.97	42.24	42.52	42.80	43.03	43.27
6.0	39.53	40.55	41.06	41.77	42.40	43.15	43.62	44.02	44.37	44.65	44.92	45.20	45.47	45.71
7.0	41.50	42.56	43.07	43.86	44.49	45.24	45.75	46.18	46.50	46.81	47.13	47.40	47.64	47.91
8.0	43.39	44.49	45.04	45.79	46.46	47.24	47.80	48.19	48.54	48.90	49.17	49.45	49.72	50.00
9.0	45.08	46.22	46.81	47.64	48.31	49.13	49.72	50.16	50.51	50.87	51.18	51.46	51.77	52.05
10.0	46.57	47.83	48.43	49.33	50.08	50.98	51.61	52.09	52.48	52.83	53.19	53.50	53.82	54.13
11.0	48.07	49.45	50.12	51.14	51.97	52.95	53.62	54.13	54.61	55.00	55.39	55.75	56.06	56.42
12.0	49.57	51.14	51.89	52.99	53.94	55.04	55.79	56.38	56.89	57.36	57.76	58.19	58.54	58.94
13.0	51.26	52.99	53.82	55.04	56.06	57.32	58.15	58.78	59.37	59.84	60.31	60.75	61.18	61.61
14.0	53.54	55.31	56.18	57.44	58.50	59.80	60.63	61.30	61.89	62.40	62.87	63.35	63.78	64.21
15.0	56.54	58.19	59.02	60.20	61.18	62.40	63.19	63.82	64.37	64.84	65.28	65.71	66.14	66.54
16.0	59.45	60.91	61.61	62.68	63.54	64.61	65.31	65.91	66.38	66.81	67.20	67.60	67.95	68.31
17.0	61.42	62.76	63.39	64.33	65.12	66.06	66.69	67.20	67.64	68.03	68.39	68.70	69.06	69.37
18.0	61.73	63.03	63.66	64.61	65.39	66.34	66.97	67.44	67.87	68.27	68.62	68.98	69.29	69.61

Source: Calculated from National Center for Health Statistics (1977, Table 13, p. 37).

Table 17: Modern Stature in Inches at Various Percentiles, Females at Nearest Birthday

Age at Nearest Birthday	Percentile													
	0.1	0.5	1.0	2.5	5	10	15	20	25	30	35	40	45	50
3.0	31.69	32.56	32.99	33.62	34.17	34.80	35.24	35.59	35.87	36.14	36.38	36.61	36.81	37.05
4.0	34.57	35.47	35.91	36.54	37.09	37.76	38.19	38.50	38.82	39.09	39.33	39.57	39.76	40.00
5.0	36.93	37.87	38.35	39.02	39.61	40.28	40.75	41.10	41.42	41.69	41.97	42.20	42.44	42.68
6.0	38.86	39.92	40.43	41.14	41.77	42.52	43.03	43.43	43.74	44.06	44.33	44.61	44.88	45.12
7.0	40.51	41.69	42.24	43.07	43.74	44.61	45.16	45.59	45.94	46.30	46.61	46.93	47.20	47.48
8.0	42.13	43.39	44.02	44.92	45.67	46.61	47.20	47.68	48.11	48.46	48.82	49.13	49.45	49.76
9.0	43.82	45.20	45.87	46.81	47.64	48.62	49.29	49.80	50.24	50.67	51.02	51.38	51.69	52.05
10.0	45.75	47.20	47.91	48.94	49.80	50.83	51.54	52.09	52.56	52.99	53.39	53.74	54.09	54.45
11.0	48.11	49.57	50.31	51.38	52.24	53.31	54.02	54.57	55.08	55.51	55.91	56.26	56.65	57.01
12.0	50.94	52.40	53.11	54.13	55.00	56.02	56.73	57.28	57.76	58.19	58.54	58.94	59.29	59.65
13.0	53.50	54.88	55.55	56.54	57.36	58.39	59.06	59.57	60.04	60.43	60.83	61.18	61.50	61.85
14.0	54.96	56.30	56.97	57.95	58.78	59.76	60.39	60.91	61.38	61.77	62.13	62.48	62.83	63.15
15.0	55.47	56.85	57.52	58.50	59.29	60.28	60.94	61.46	61.89	62.32	62.68	63.03	63.35	63.70
16.0	55.87	57.20	57.87	58.82	59.61	60.59	61.22	61.73	62.17	62.56	62.91	63.27	63.62	63.94
17.0	56.57	57.83	58.46	59.37	60.12	61.02	61.65	62.13	62.56	62.91	63.27	63.58	63.90	64.21
18.0	57.32	58.50	59.09	59.92	60.63	61.50	62.05	62.52	62.91	63.23	63.54	63.86	64.17	64.45

Source: Calculated from National Center for Health Statistics (1977, Table 13, p. 37).