Data from the
NATIONAL HEALTH SURVEY

Series 11
Number 149

Skeletal Maturity of Children 6-11 years:

Racial, Geographic Area, and Socioeconomic Differentials

United States

Skeletal age (hand-wrist) and bone-specific skeletal ages (as determined using the Health Examination Survey standard based on the Greulich-Pyle Radiographic Atlas) of boys and girls 6-11 years of age, by chronological age, race, geographic region, population size or land use of area of residence, annual family income, and education of parent.

DHEW Publication No. (HRA) 76-1631

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service

Health Resources Administration
National Center for Health Statistics
Rockville, Md. October 1975

Library of Congress Cataloging in Publication Data

Roche, Alexander F.
Skeletal maturity of children 6-11 years: Socioeconomic differentials.

(National Center for Health Statistics. Data from National Health Survey, series 11, no. 149) (DHEW publication no. (HRA) 76-1631)
Includes bibliographical references.
Supt. of Docs. no.: HE 20.2210:11/149
1. Children—Growth—Testing. 2. Bone—Growth—Statistics. 3. Children in the United States—Anthropometry. I. Roberts, Jean, joint author. II. Hamill, Peter V. V., joint author. III. Title. IV. Series: United States. National Center for Health Statistics. Vital and health statistics. Series 11: Data from the National Health Survey. Data from the health examination survey, no. 149. V. Series: United States. Department of Health, Education, and Welfare. DHEW publication no. (HRA) 76-1631. [DNLM: 1. Age determination by skeleton. 2. Bone development. 3. Hand—Growth & development. 4. Socioeconomic factors. W2 A N148vk no. 149]
RA407.3.A347 no. 149 [RJ13] 312'.0973s [312'.6]
ISBN 0-8406-0030-5 75-18049

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 - Price $1.45

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In accordance with specifications established by the National Center for Health Statistics, 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.

Vital and Health Statistics-Series 11-No. 149

DHEW Publication No. (HRA) 76-1631

Library of Congress Catalog Card Number 75-18049

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SKELETAL MATURITY
OF CHILDREN 6-11 YEARS:
RACIAL, GEOGRAPHIC AREA, AND SOCIOECONOMIC DIFFERENTIALS

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INTRODUCTION

This report contains national estimates of the levels of skeletal maturity in the hand-wrist of noninstitutionalized children in the United States 6-11 years of chronological age by race, area of residence, and socioeconomic background, as determined in the Health Examination Survey of 1963-65. The previous report on these radiographic findings,[1] which was limited to the sex differences in skeletal maturity in relation to chronological age, contains a more comprehensive description of the nature of skeletal maturation and of the assessment method used in the Survey.

The Health Examination Survey is one of the major programs of the National Center for Health Statistics, authorized under the National Health Survey Act of 1956 by the 84th Congress as a continuing Public Health Service function to determine the health status of the population.

In carrying out the intent of the National Health Survey,[2] four different types of survey programs are used. The Health Interview Survey collects health information from samples of people by household interview with a responsible adult and is focused primarily on the impact of illness and disability within various population groups. The programs in the Divisions of Health Resources Utilization Statistics and Health Manpower and Facility Statistics obtain health data as well as health resource and utilization information through surveys of hospitals, nursing homes, and other resident institutions, and also data on the entire range of personnel in health-related occupations. The Health Examination Survey collects health data by direct physical examination, tests, and measurements performed on samples of the population. The latter program provides the best way of obtaining the actual prevalence of certain medically defined illnesses. It is the only effective way to secure information on unrecognized and undiagnosed conditions and on a variety of physical, physiological, and psychological measures within the population. Also it collects demographic and socioeconomic data on the sample population under study to which the examination findings may be related.

The Health Examination Survey (HES) is organized as a series of separate programs, or cycles, each of which is limited to some specific segment of the United States population and to specific aspects of health. In the first cycle, the prevalence of certain chronic diseases and the distribution of various physical and physiological measures were determined on a cross section of the defined adult population, as previously described.[3,4]

In the program on which the findings in this report ~~are based~~, a probability sample representative of the approximately 24 million noninstitutionalized children aged 6-11 years in the United States was selected and examined. The examination in this cross-sectional study primarily assessed health factors related to growth and development. It included an examination by a pediatrician and by a dentist, tests administered by a psychologist, and a variety of tests and measurements administered by a technician. A more complete description of the survey plans, sample design, examination content, and operation of the Survey has been published.[5]

Field collection operations for this cycle were started in July 1963 and completed in December 1965. There were 7,417 children selected in the sample, of whom 7,119, or 96 percent, were examined. This national probability sample is representative, and those examined are closely representative of the approximately 24 million noninstitutionalized children aged 6-11 years in the United States with respect to age, sex, race, region, size of place of residence, and rate of change in size of place of residence from 1950 to 1960. Of the children examined, 157 were not radiographed or had radiographs taken for the Survey that were not suitable for assessment. Thus, the skeletal maturity estimates for United States children 6-11 years are based on the remaining 6,962 children, or 94 percent of the original sample.

The examining team gave each child a standardized examination during his single visit in the mobile units specially designed for use in the Survey. Demographic and socioeconomic data on household members as well as medical history, behavioral, and related data on the child to be examined were obtained from his parents prior to his examination. Ancillary data were requested from the school attended by the child, including his grade placement, school behavior, adjustment, and health problems. Birth certificates for verification of the child's age and information related to his condition at birth were obtained also.

The present analysis concerns differences in skeletal maturity levels for the United States population aged 6-11 years, grouped according to race, region, and socioeconomic status. The general concept of skeletal maturity, the method by which radiographs were taken and later assessed, and the quality control measures used have been described and discussed.[1] The present findings provide normative national data. They are interpreted in regard to the health significance of skeletal maturity status and compared with findings from other studies. Not all relevant reports have been included in the literature review, some because the sample size was inadequate but others because of inadequate documentation concerning the repeatability and comparability of the skeletal age assessments. In later reports, the skeletal ages of these children will be considered in relation to body size, body composition, and other variables.

A brief description of the sample design, quality control methods, reliability of the data, as well as population and sampling error estimation procedures used for the findings of this study is contained in appendix I. Definitions of the demographic terms used in the report are included in appendix II, and an evaluation of the reliability of the assessments is shown in appendix III.

EXAMINATION METHOD

At each of the 40 preselected locations throughout the United States used consecutively in this cross-sectional study, the children were brought to the centrally located mobile examination center for a standardized examination that lasted about 2½ hours. Six children were examined in the morning and six in the afternoon. When each child entered the mobile center, his oral temperature was taken and a screening for acute illness was made. If such illness were detected, the child was sent home and reexamined later. Each examinee next dressed in shorts, cotton sweat socks, and a light sleeveless shirt and proceeded to a designated but different station for the examination. The sequence of elements in the examination differed for each child, so that the six could be examined simultaneously during the half day. The same examiners—physician, dentist, psychologist, and specially trained technicians—conducted their parts of the examination in essentially the same manner for each child. The time of each part of the examination was recorded, but there is no reason to believe that diurnal or sequence effects would be present in the composition or quality of the radiographic data.

Field Radiography

Each child was scheduled to have a 10" X 12" radiograph taken of the right hand and wrist for which the positioning was otherwise in accordance with specifications in the Greulich-Pyle Atlas.[6] Some radiographs were made using other film sizes when the 10" X 12" size was scarce; this would not have influenced the findings. Technically inadequate films could be repeated because they were developed immediately in the field. Thus, each child's record contains a single radiograph showing the dorsopalmar view of his entire hand-wrist with its full complement of ossifying parts, at his examination age.

The decision to radiograph the right hand-wrist rather than the left, which is the more frequent anthropometric practice, was made on the advice of anthropologist consultants who were interested also in the use of related measurement data for equipment design in which right-side measurements were preferred. When the selected plates from Greulich-Pyle Atlas standards and those from other sources were reproduced in the HES Standard, they were reversed photographically so that they could be used in right-side assessments. Previous reported research[7] on lateral differences in the skeletal maturity of the hand-wrist, either for the area as a whole or bone by bone, has shown that these are too small to be of practical importance.

Training of Assessors

The assessment of skeletal age from the hand-wrist radiographs of children 6-11 years of age in the Health Examination Survey of 1963-65 was made by six medical students at Case Western Reserve University, one of whom was an instructor specializing in anatomy. This work was done under contract for the National Center for Health Statistics, with Dr. P. Wesley Dupertius as Project Director. Training of the assessors and implementing the related quality control procedures were done in the meticulous manner previously described[1] under the direction of Dr. S. I. Pyle. When the ratings and reliability for the new assessor were in good agreement with those of Dr. Pyle (the majority of differences within 4 months) the new assessor started his assessments of the survey radiographs. Reported evidence[8] suggests that, at the end of the training procedure, the interobserver and intraobserver differences in skeletal maturity ratings were similar to those for experienced assessors.

Assessment Procedure

The radiographs were assessed by comparison with prints of the series of standards for the male hand-wrist selected from those in the 1959 Greulich-Pyle Atlas[6] and other sources. These were reversed so that they appeared to be of the right hand-wrist as shown in the 1971 *Radiographic Standard of Reference* of Pyle, Waterhouse, and Greulich.[9] This standard contains the male skeletal age equivalents that were used during the assessment of Cycle II radiographs (ages 6-11 years), with some very slight modification to smooth the skeletal age trend for a few of the bones.

The readers did not have access to the chronological age, sex, or other information about the child. Each bone was assessed separately and interpolation was made between the standards to monthly intervals when this appeared appropriate.

As a quality control measure and to permit determination of the level of reliability of the assessments throughout this study, independent replicate assessments were obtained on approximately 1 out of each 11 films. One randomly selected radiograph in each 23 was rated independently by another assessor for a measure of interobserver variability and 1 randomly selected radiograph among each 20 was rated independently a second time by the same reader to give a measure of intraobserver variability. The time lapse between the first rating and the reassessment was sufficiently long that there was little likelihood of recall. Furthermore, there was no indication to the assessor that he was making a reassessment. Information on the degree of reliability of assessments from this survey has been published.[1]

The order in which the bones were assessed within each radiograph was the same as that in which they are listed in table A. This table also shows the minimum and maximum individual bone-specific skeletal ages allowable in this

Table A. Minimum and maximum acceptable skeletal ages (in months) using the HES Standard

Hand-wrist bone	Minimum[1]	Maximum[2]
	Skeletal age in months	
Radius	15	228
Ulna	69	215
Capitate	---	197
Hamate	---	197
Triquetral	17	197
Lunate	35	197
Scaphoid	68	197
Trapezium	51	197
Trapezoid	68	197
Metacarpal I	25	191
Metacarpal II	17	215
Metacarpal III	16	209
Metacarpal IV	17	209
Metacarpal V	24	215
Proximal phalanx I	33	215
Proximal phalanx II-V	15	209
Middle phalanx II-IV	23	209
Middle phalanx V	39	209
Distal phalanx I	15	191
Distal phalanx II, V	39	191
Distal phalanx III	22	191
Distal phalanx IV	32	191
Pisiform	110	197
Adductor sesamoid	146	197
Flexor sesamoid	158	197

[1]Minimum age (according to standard) of the radio-opacity of the epiphysis or carpal.

[2]One month below "adult" age.

study. The lower limit for the bone-specific skeletal age was arbitrarily set midway in skeletal age (hand-wrist) between the last standard in which the particular bone was not radio-opaque and the first in which it was radio-opaque. Exceptions were made for the three later ossifying bones—the pisiform and the adductor and flexor sesamoids—for which minimum ages allowed were 2 months above the last standard in which they were not radio-opaque.

There are limits also at the upper end of the range when bones become adult. Only the designation "adult," and not a skeletal age in months, can be assigned to a bone in which maturation is complete. Median ages in months from the HES Standard at which this occurs in boys were used as the skeletal age for each bone beyond which only the designation "adult" could be applied. The maximum allowable values 1 month below the "adult" skeletal age are shown in table A.

As expected, within chronological age groups, the skeletal ages assigned to girls were more advanced than those assigned to boys. This occurs because, although boys and girls pass through the same skeletal maturity stages, girls tend to mature more rapidly than boys. The female equivalent skeletal ages were determined during the preparation of the HES Standard, but were not used in the assessment of the Survey radiographs. The method by which these female equivalent skeletal ages were obtained has been described in detail by Pyle et al.[9]

The skeletal age data for girls in the detailed tables of this report are given both in terms of the male standards, as originally assessed, and in terms of the female equivalent skeletal ages. *However, the findings for girls in the text are limited to the female equivalent skeletal ages.* The skeletal age values for the whole hand-wrist for boys and girls in this report were determined by computer from the original bone-specific assessments by averaging the ages assigned the hand-wrist bones for each child.

SKELETAL AGE (HAND-WRIST) FINDINGS

Among both boys and girls 6-11 years of age in the United States (considering only the female equivalent values for girls), skeletal age (hand-wrist) was found, on the average, to be consistently less than chronological age. The mean sex-associated differences increase steadily with chronological age. Comparison of skeletal age for boys with the female equivalent values for girls shows close agreement (mean difference less than 1 month) among children 7 and 8 years of age at their last birthday, while among younger and older children of 6 and 9-11 years, the means for boys are substantially less advanced than those for girls, by 2 to 3 months. Boys showed no consistent pattern in the variability of skeletal age (hand-wrist) with chronological age, but older girls were slightly more variable than younger girls in this respect. Except at ages 9 and 10 years, boys showed slightly greater relative variability than girls in their skeletal ages. These national estimates, which have been reported previously,[1] are based on data from the National Health Examination Survey of 1963-65 in which assessments of hand-wrist radiographs were made using the HES Standard based primarily on the Greulich-Pyle Radiographic Atlas.[6]

Previous international research has shown clearly that children of different racial groups vary in body size and in levels of skeletal and sexual maturity at corresponding chronological ages.[10-15] Factors influencing the rate of the apposition or resorption of bone in skeletal maturation are related to genes, nutrition, illness, or climate. Only in a few studies, however, have the possible effects of these factors been separated. Interactions between these factors make it difficult to draw definitive conclusions from reported findings outside the context of animal experimentation. Knowledge is almost entirely lacking concerning the effects of specific groups of genes—e.g., autosomal, sex-linked—or the effects of quantitative, measurable environmental factors—e.g., protein intake, temperature—on skeletal maturation in children.

This report contains information on the racial, geographic region, urban-rural, and socioeconomic differentials in the skeletal maturity of United States children. These findings are compared with relevant research findings from previous studies.

Race

The skeletal maturity of white boys and girls 6-11 years of age generally tends to be somewhat less advanced than that of Negro boys and girls in the United States of corresponding chronological age. The number of children of other races in this country, and hence in the study sample, is too small to provide reliable estimates for this heterogeneous segment of the population.

Among white boys, the mean skeletal age (hand-wrist) is consistently lower than that of their Negro counterparts, except for those 10 years of age at their last birthday (figure 1 and

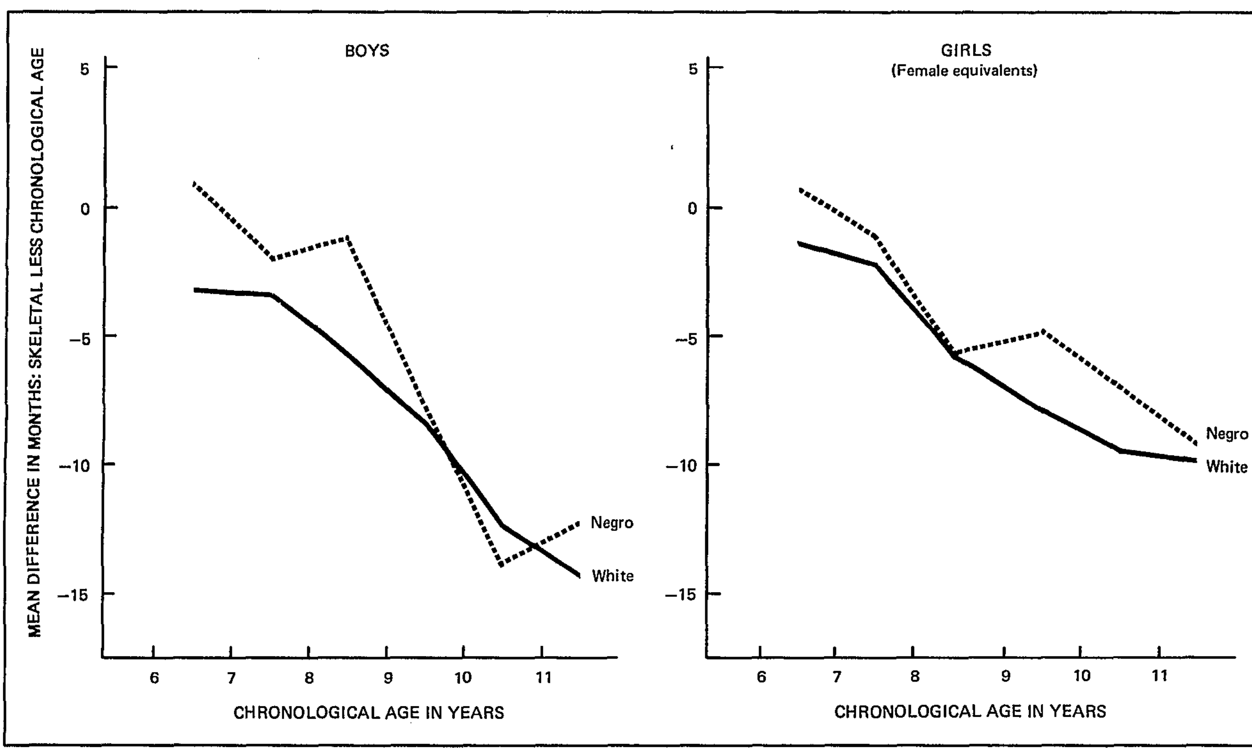

Figure 1. Mean difference in months between skeletal age (hand-wrist) and chronological age for white and Negro boys and girls, by chronological age in years: United States, 1963-65.

table 1). At all but 6 and 8 years (chronological age) where the skeletal age means for Negro boys exceed those for white boys by more than 4 months, the mean differences between the races in skeletal age are small (1 to 2 months). With the size and design of the sample used in this study, they could easily reflect sampling variability alone (i.e., the differences are not statistically significant at the 5-percent probability level using standard parametric tests—see appendix I). These differences are also not significant when data for all ages are combined.

The mean skeletal age (hand-wrist) of white girls (female equivalent values) also lags behind that for their Negro counterparts, except for those 8 years of age at their last birthday where the mean values are identical. For the remainder of the girls, mean differences vary between 0.7 month at chronological age 11 years and 2.7 months at age 10 years. All of these differences are within the 95-percent confidence limit for such estimates and hence could reflect sampling variability alone. When data are combined for 6-11 years, these white-Negro differences are statistically significant for boys but not girls.

When indirect adjustments are made for any differences in the age distributions among white and Negro children (assuming that the national age-specific mean values apply identically in both racial groups), the contrast in skeletal maturity between the two racial groups is even more clear. This is shown for all ages combined in figure 2.

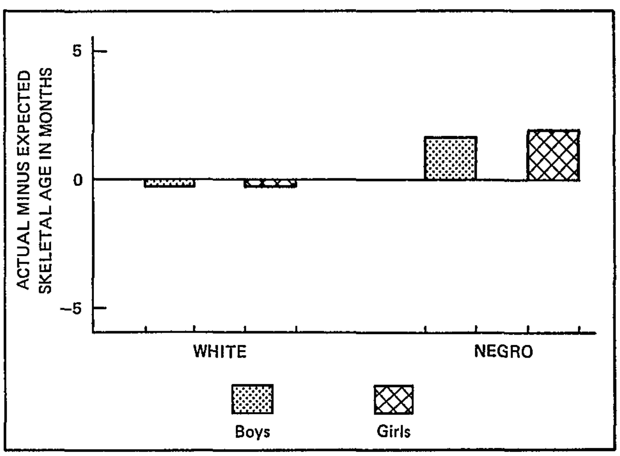

Figure 2. Difference between actual and expected mean skeletal age (hand-wrist) for white and Negro boys and girls 6-11 years of chronological age: United States, 1963-65.

Among white children, girls are generally more advanced than boys in their skeletal age (hand-wrist) except at chronological age 8 years when the mean values are identical (figure 3). The differences in mean skeletal age for the remainder range from 1.2 months at age 7 years to 4.3 months among the oldest children at age 11 years. Among the youngest and oldest children—those of chronological ages 6, 10, and 11 years—the mean differences exceed the 95-percent confidence limit for such estimates and hence are not likely to be due to sampling variability alone.

Negro girls of chronological ages 9-11 years are also generally more advanced in skeletal age than Negro boys by mean values of 2.9, 7.0, and 3.0 months, respectively. The differences at 9 and 11 years are too small to be considered statistically significant (at the 5-percent probability level). Among younger Negro children of 6 and 7 years (chronological age), the mean differences in skeletal age between boys and girls are negligible, but among those 8 years of age at their last birthday, Negro boys were more advanced than Negro girls in skeletal age (female equivalent values) by more than 4 months.

The variation in skeletal age (hand-wrist) among children of chronological ages 6-11 years in this country shows no consistent pattern of racial differences. White boys of chronological ages 6, 8, and 9 years are relatively more variable in skeletal age than Negro boys while at ages 7, 10, and 11 years the reverse was found (figure 4 and table B). White girls at all ages except 7 and 10 years, where the differences were small, are somewhat less variable in this respect than Negro girls. The pattern of relative variability between boys and girls differs for white and Negro children. Among white children, boys showed greater relative variability in skeletal age than girls in four of the six age groups—6-8 and 11 years—while among Negro children, boys were less variable than girls in skeletal age at all but 7 years of age. The patterns of sex differences in variability, across age, were more regular in white than in Negro children. This greater stability in the white children probably reflects the greater sample size for them.

Other studies (white).—Comparison with racial findings for skeletal maturity of United States children from the present national survey is

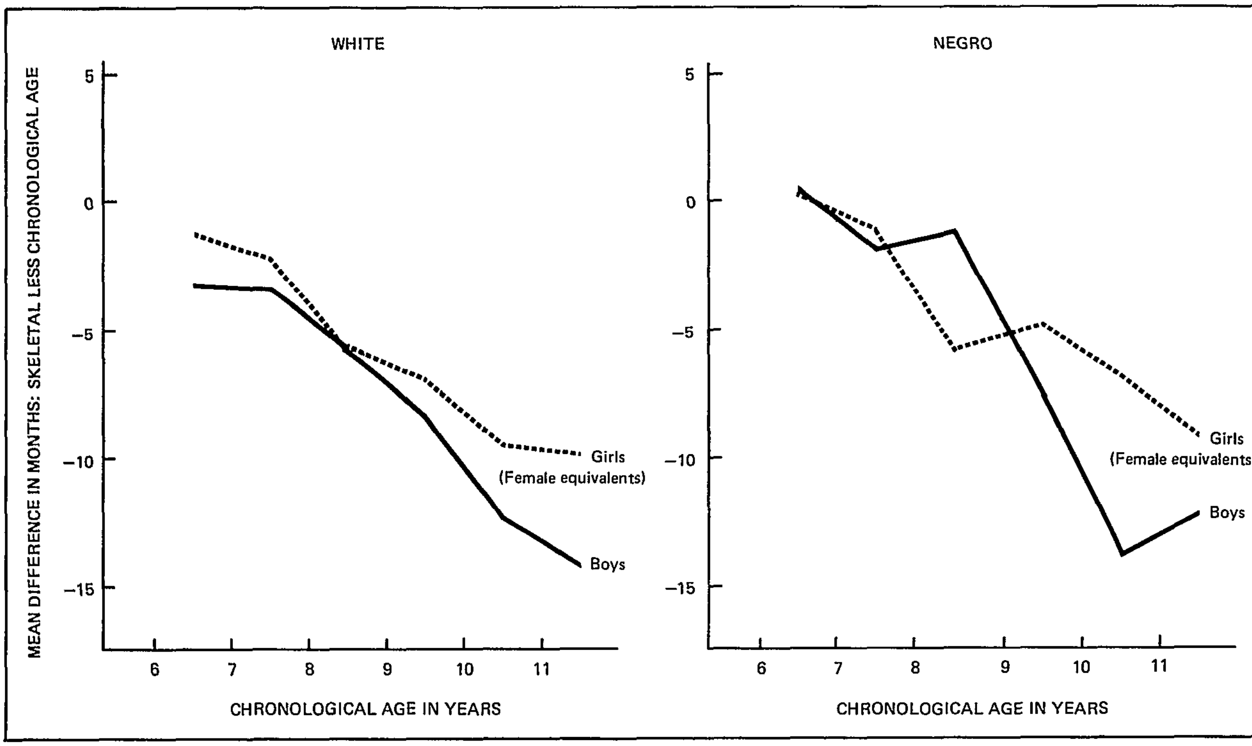

Figure 3. Mean difference in months between skeletal age (hand-wrist) and chronological age for white boys and girls and Negro boys and girls, by chronological age in years: United States, 1963-65.

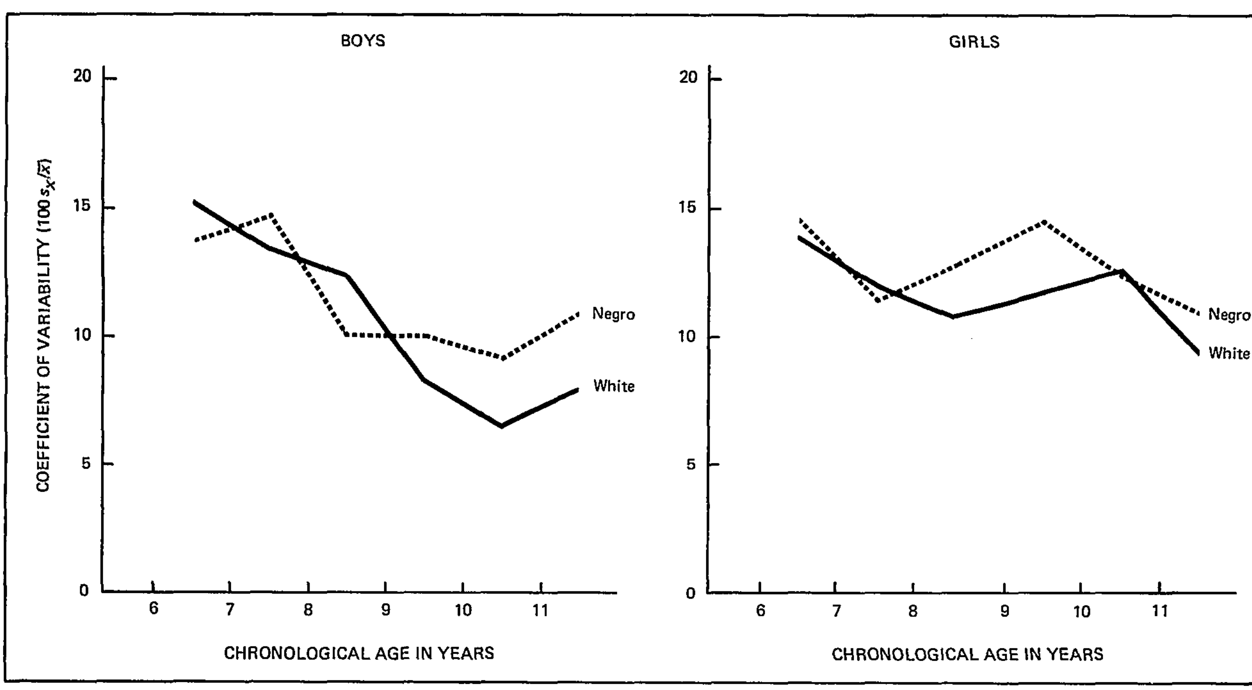

Figure 4. Relative variability in skeletal age (hand-wrist) among white and Negro boys and girls, by chronological age in years: United States, 1963-65.

Table B. Coefficients of variability of skeletal age within chronological age groups

Chronological age	Boys		Girls	
	White	Negro	White	Negro
	Coefficient of variation (100 $s_x/\bar{x}$)			
6 years	15.3	13.6	13.9	14.6
7 years	13.4	14.7	12.0	11.5
8 years	12.4	10.0	10.8	12.8
9 years	10.8	10.0	11.7	14.6
10 years	9.0	9.2	12.6	12.5
11 years	10.5	10.9	9.4	11.0

limited primarily to previous studies among various subgroups of children in this country.

The skeletal maturity (hand-wrist) data for white children from seven previous studies in this country (some longitudinal and some at a single point in time) and the United States estimates for 1963-65 from the present national cross-sectional study are shown in figures 5-8. Data from the previous studies have been adjusted to a common Greulich-Pyle zero line to facilitate comparisons among them and with the present study. Data from the previous studies relate to mean, median, or approximate modal values of skeletal age (hand-wrist) within chronological age groups and are shown as the difference between skeletal and chronological

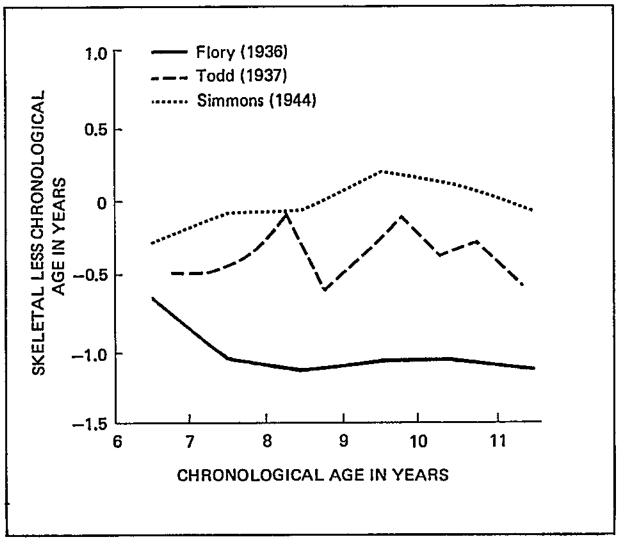

Figure 5. Differences between skeletal and chronological ages of boys by chronological age in years, in studies of Flory (1936), Todd (1937), and Simmons (1944).

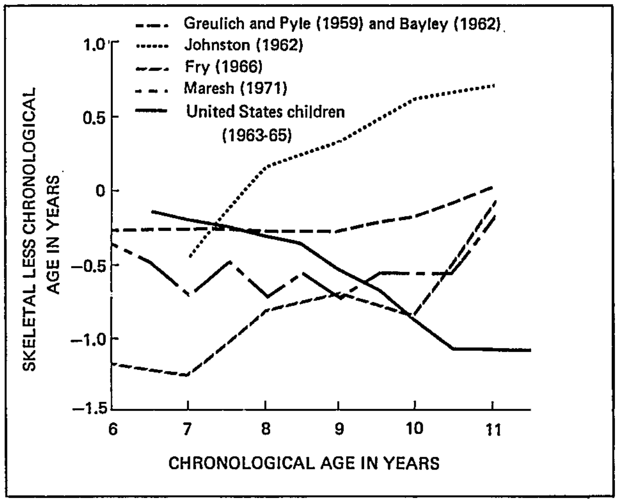

Figure 6. Differences between skeletal and chronological ages of boys, by chronological age in years, in studies of Greulich and Pyle (1959), Bayley (1962), Johnston (1962), Fry (1966), and Maresh (1971), and for United States children (1963-65).

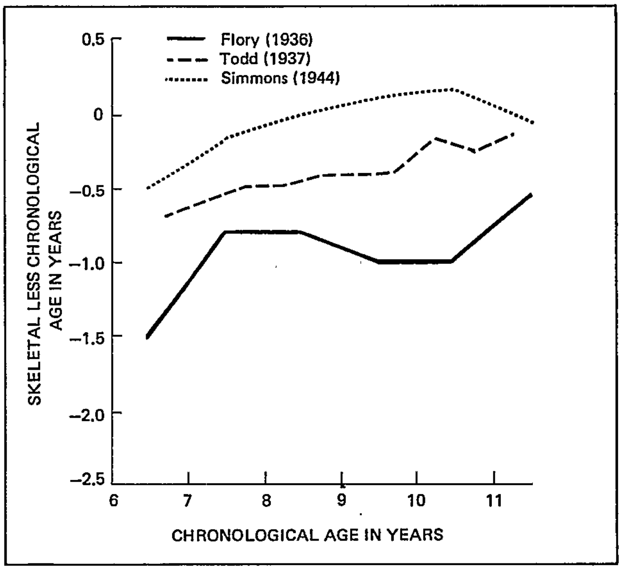

Figure 7. Differences between skeletal and chronological ages of girls (female equivalent values for the former), by chronological age in years, in studies of Flory (1936), Todd (1937), and Simmons (1944).

age within chronological age groups in these figures. Values above the zero line show acceleration in skeletal maturity (skeletal age exceeds chronological age) and those below the zero line show retarded skeletal age. The 1959 Greulich-Pyle standards[6] were selected from radiographs of white children of upper socioeconomic status

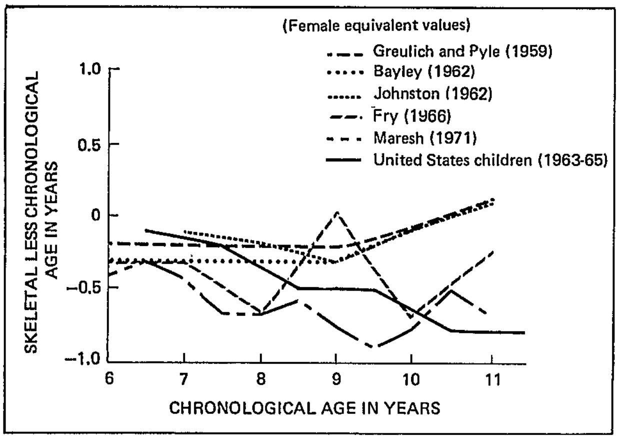

Figure 8. Differences between skeletal and chronological ages of girls (female equivalent values for the former) by chronological age in years, in studies of Greulich and Pyle (1959), Bayley (1962), Johnston (1962), Fry (1966), and Maresh (1971), and for United States children (1963-65).

living in Cleveland. These children were born between 1917 and 1942 and were radiographed close to birthdays and half-birthdays, as previously described.[1] The method by which these standard plates were selected from the 100 radiographs available for each sex at each age is described in the Atlas of Greulich and Pyle.[6]

The mixed longitudinal data of Flory[16] were obtained from white Chicago children of above-average socioeconomic status who were born between 1911 and 1923 and were radiographed close to each birthday. Flory selected from the 100 radiographs available for each sex at each age (except at 6 and 7 years when at least 80 radiographs were available) those radiographs that he considered best represented the central tendencies of skeletal maturity in his groups. The selected radiographs are about 1 year retarded in maturity in comparison with corresponding Greulich-Pyle standards (figures 5 and 7). Simmons[17] reported data from Cleveland children, most of whom were included in the sample studied by Greulich and Pyle[6] and who had been radiographed near each birthday. The sample size varied from 154 to 206 for each year of age for each sex. The means reported by Simmons, after adjustment for the use of Todd standards,[18] were within 0.5 year (skeletal age) of the Greulich-Pyle standards.

Todd[18] published standards derived from white Cleveland children of all socioeconomic levels. These children were born between 1920 and 1930 and radiographed near each birthday and half-birthday. The sample size within each age-sex group varied from 35 to 94 children. The standard plates were chosen to represent the central tendencies for skeletal maturity level within these age-sex-specific groups. The Todd standards (from all socioeconomic groups) were at lower levels than those of Greulich and Pyle (from upper socioeconomic groups). The Todd values were also lower than the mean skeletal maturity levels reported by Simmons (from upper socioeconomic groups) but exceeded those of Flory (from average socioeconomic groups).

Bayley[19] reported data from the Harvard Growth Study of white children of middle socioeconomic status, living in Boston, born between 1930 and 1939, and examined near each birthday. The sample size varied from 63 to 67 in each age-sex group. The mean skeletal ages (Greulich-Pyle) for these children were very close to their mean chronological ages. Johnston[20] reported mixed longitudinal data for middle-class white Philadelphia children born between 1937 and 1955. The ethnic strains in this sample were (in order of frequency) Italian, Scotch, Irish, English, Polish, Russian, and Ukranian, with many Jews included among the East Central European peoples.[21] These children were radiographed at random chronological ages, and the sample size varied from 23 to 51 for each annual interval in each sex. All mean skeletal ages were within 0.5 year of the Greulich-Pyle standards except in 10- and 11-year-old boys who were about 0.6 to 0.7 year ahead of the Greulich-Pyle standards (figure 6). It would be tempting to conclude that the skeletal advancement of these boys reflects their ethnic origins, but this factor should then have operated equally in girls which it did not (figure 8).

Cross-sectional skeletal age data from white Nebraska children of middle socioeconomic level have been reported by Fry (1966).[22] These children were born between 1950 and 1960 and were radiographed at random ages. The sample included 25 children of each sex within each annual interval. The means were below the Greulich-Pyle standards, particularly in 6- and 7-year-old boys. Maresh[23] reported mixed longitudinal data from upper middle class white Denver children. The children were born between 1915 and 1964, but most of the radiographs were taken after 1947 and close to birthdays and half-birthdays. The sample size ranged from 39 to 57 for each 6-month interval in each sex. The median skeletal ages for these children were about 0.5 year below Greulich-Pyle standards from 6-11 years.

Comparable findings for United States white children in the present national study, that would be closely representative of all socioeconomic groups in the country, show a distinct pattern of increasing retardation in skeletal maturity with chronological age. This tendency was evident among boys in the earlier studies[16-18] and is in sharp contrast to the age-pattern among boys in the more recent studies.[19,20,22,23] The increasing retardation or lag of skeletal age behind chronological age as chronological age increases among U.S. children differs from the findings in both earlier and more recent studies among selected groups of girls. The findings for 10- and 11-year-old children from the present national study are more consistent with those of Flory[16] than with those of the other studies.

The present national study as well as the previous studies among more geographically limited groups of the United States population show that sex differences in mean levels of skeletal maturity were small. This does not indicate that girls did not mature more rapidly than boys, but that, when assessments were made against sex-appropriate standards, the differences between the mean skeletal ages for the two sexes were slight. The exceptions were in the group studied by Fry[22] in which girls had higher mean skeletal ages than boys throughout the 6-11 year age-range and in the group studied by Johnston,[20] in which boys had higher mean skeletal ages than girls at all ages 6-11 years.

While the present national study does not provide reliable skeletal maturity data showing differentials by specific ancestry among white children in the United States, available information on white children in this country whose parents were foreign born or of foreign ancestry and on child populations from countries that have contributed substantially by emigration to the United States population are described below insofar as they may provide some further insight into variations in skeletal maturity among white children in this country.

Only one previous study is available on the skeletal maturity status of some white United States children by more specific ancestry. Todd[24] reported insignificant differences in maturity status between 315 United States children both of whose parents were born in Italy (usually southern Italy or Sicily) and 201 children both of whose white parents were born in the United States.

Some information concerning skeletal maturity levels of groups of British, Danish, and United States children is available from studies of the differences between Greulich-Pyle[6] and Tanner-Whitehouse[25] assessments of the same radiographs by Fry,[22] Andersen,[26] Asiel,[27] Roche et al.[28] and Blanco et al.[29] The data are summarized in table C. No matter what the group of radiographs, if they are assessed by both methods, the two sets of recorded skeletal ages provide data about the relative level of maturity in British (Tanner-Whitehouse) and United States (Greulich-Pyle) children. Such comparisons are indirect but valid except that they are limited by the unrepresentative nature of the samples on which these two methods are based. It is important to note that the Tanner-Whitehouse standardizing sample consisted of 1,826 children in southwestern Scotland who were examined cross-sectionally, 387 English children studied longitudinally, and 351 English children studied cross-sectionally. All reported comparisons show higher mean values for Tanner-Whitehouse skeletal ages than for Greulich-Pyle skeletal ages. Theoretically, these differences could be due to differential weighting of bone-specific skeletal ages between the two methods, but it has been shown that this is *not* an important factor.[28] There is no doubt that the reported differences almost entirely reflect variations between the standardizing samples used by Greulich and Pyle[6] and by Tanner et al.[25] Consequently, they can be interpreted as showing the differences in skeletal maturity status between a group of children in Cleveland and a group of children in southwestern Scotland and England. The sample of Fry[22] has been described earlier.[1] Andersen[26] reported cross-sectional data from Copenhagen

Table C. Mean differences (years) between Greulich-Pyle and Tanner-Whitehouse assessments of the same radiographs

Sex and chronological age	American-Nebraska (Fry, 1966)[22]	Danish-Copenhagen (Andersen, 1968)[26]	Australian-British ancestry (Roche et al., 1971)[28]
	Mean difference		
Boys			
6.0 years	–1.0	—	–1.2
7.0 years	–1.3	–0.4	–1.3
8.0 years	–1.4	–1.1	–1.2
9.0 years	–1.4	–0.6	–1.0
10.0 years	–1.4	–0.4	–0.7
11.0 years	–1.0	–0.3	–0.5
Girls			
6.0 years	–0.8	—	–1.1
7.0 years	–1.1	–0.4	–1.1
8.0 years	–1.4	–0.9	–1.1
9.0 years	–1.3	–0.9	–0.8
10.0 years	–1.0	–0.7	–0.6
11.0 years	–0.7	–0.7	–0.7

children with a wide range of socioeconomic levels. The number of children varied from 43 to 68 for each annual interval in each sex. The analysis by Roche et al.[28] was based on mixed longitudinal data from 62 boys and 82 girls of British ancestry who were born in Melbourne, Australia, where they were living at the time of the study. The differences reported by Fry[22] and Roche et al.[28] are similar until ages 9-11 years in boys and 9-10 years in girls when those reported by Fry are greater. Those reported by Andersen[26] are less at all ages except 8 years in boys and 9-11 years in girls. Generalizing, these studies indicate that the standardizing sample of Tanner et al.[25] was about 0.6 to 1.1 years behind the Greulich-Pyle sample in mean skeletal maturity level. The radiographs were assigned the same levels in "skeletal age years" when used as standardizing samples. However, when the two sets of standards are both applied to other groups, ratings by the Tanner-Whitehouse method tend to be greater than the corresponding ratings by the Greulich-Pyle method.

The mixed longitudinal data of Roche[30] were from essentially the same sample as that studied by Roche et al.[28] The mean Greulich-Pyle skeletal ages in these Australian children of British ancestry were very close to the mean chronological ages (table D). This finding that children of British ancestry born and living in Australia mature more rapidly than children in southwestern Scotland and England included in the standardizing sample of Tanner et al., could be due to the combined effects of several of the factors mentioned earlier (i.e., genes, nutrition, illness, and climate).

Table D. Modal differences between skeletal age and chronological age (Greulich-Pyle SA – CA in years) in "European" children

Sex and chronological age	Australian-British ancestry (Roche, 1967)[30]	Danish-Copenhagen (Andersen, 1968)[26]
	Modal difference (years)	
Boys		
6.0 years	0.0	—
7.0 years	0.0	–0.6
8.0 years	+0.2	–0.9
9.0 years	+0.2	–0.5
10.0 years	+0.3	–0.4
11.0 years	+0.2	–0.5
Girls		
6.0 years	–0.1	—
7.0 years	–0.2	–0.4
8.0 years	0.0	–0.6
9.0 years	0.0	–1.0
10.0 years	0.0	–0.5
11.0 years	–0.1	–0.6

Kopczynska[31] reported cross-sectional data from 12,000 Polish children aged 7 to 16 years in Warsaw. The mean skeletal ages (Greulich-Pyle) tended to be less than the mean chronological ages except that the differences were small in girls aged 7-10 years. At later ages the mean skeletal ages exceeded the corresponding chronological ages. Rudzinski[32] reported mixed longitudinal data from 186 Polish boys aged 9.5 to 10.5 years and from 452 Polish boys aged 10.5 to 11.5 years. The mean Greulich-Pyle skeletal ages were less than the corresponding chronological ages, but the differences were only about 0.3 year.

For the Copenhagen children studied by Andersen,[26] all group means were below the Greulich-Pyle levels by about 0.4 to 1.0 skeletal age years (table D). There was little change in mean level with age and little difference between the sexes.

In middle socioeconomic class Mexican children, Chávez et al.[33] reported that the mean skeletal age (Greulich-Pyle) was only slightly less than the mean chronological age, except in boys at about 7 years. These data provide some indication of the level of skeletal maturity to be expected in the comparable socioeconomic class of United States children of Mexican ancestry. (In the present study Mexican children are classified as white unless generally accepted as American Indian or of another race—see appendix II.)

Other studies (white-Negro).—In partial contrast to the national findings reported here which show that white children (boys and girls) tend to be less advanced in skeletal maturation than Negro children, Todd,[24] using cross-sectional radiographs of 149 Negro children, tentatively concluded that there were no modal differences in skeletal maturity level between white and Negro boys but he did find that Negro girls tended to be more advanced than white girls. Sproul and Peritz[34] reported mean skeletal ages, standardized to a chronological age of 6.5 years, for 102 upper-middle-class Negro children living in the San Francisco area. The chronological age of these children ranged from less than 5 to more than 9 years, and they were the 5 percent of the sample closest to the median stature for their age-sex specific groups. The mean differences between the Greulich-Pyle skeletal age and chronological age were very small.

Malina[35-38] made Tanner-Whitehouse assessments of middle to upper-middle socioeconomic class white children (N = 285) and lower to lower-middle socioeconomic class Negro children (N = 367) in Philadelphia aged 6 to 11 years. Both the white and Negro children were slightly in advance of the Tanner-Whitehouse standards except at a few ages where the sample sizes were small. The differences between the means for the two groups were small, with the Negro children showing a slight tendency to be advanced despite their lower socioeconomic status (table E).

Marshall et al.[39] reported cross-sectional data from 269 rural Jamaican children aged 7 to 11 years living about 15 miles north of Kingston. The mean differences between Tanner-Whitehouse skeletal ages and chronological ages (table F) were small except at 7.5 years, where the mean skeletal ages were advanced over the mean chronological ages in both the boys and the girls. These rural Jamaican children were retarded skeletally in comparison with those Negro children in Philadelphia studied by Malina.[35-37]

Other studies (other races).—While the number of children of other races (American Indian, Japanese, Chinese, and others not classified for census purposes as either white or Negro) in the United States, and hence in the sample used for

Table E. Mean differences in skeletal age (Tanner-Whitehouse, in years) between white and Negro children in Philadelphia (Malina, 1969)[36]

Sex and approximate mean chronological age	White-Negro difference
Boys	
6.2 years	–0.4
7.0 years	–0.4
8.0 years	–0.1
9.0 years	–0.2
10.0 years	+0.1
10.9 years	0.0
Girls	
6.3 years	+0.1
7.0 years	–0.3
8.0 years	+0.2
9.0 years	–0.4
10.0 years	–0.5
11.0 years	–0.7

Table F. Modal differences between skeletal age and chronological age (Tanner-Whitehouse SA – CA in years) in Negro children living abroad

Sex and approximate chronological age	Rural Jamaica (Marshall et al., 1970)[39]
Boys	
7.5 years	+0.7
8.5 years	–0.1
9.5 years	–0.1
10.5 years	–0.4
Girls	
7.5 years	+1.1
8.5 years	+0.5
9.5 years	+0.2
10.5 years	+0.1

Table G. Modal skeletal age levels (Greulich-Pyle SA – CA in years) at various chronological ages in American children of Chinese ancestry and Chinese children

Sex and approximate chronological age	Chinese ancestry-California (Sproul and Peritz, 1971)[34]	Southern Chinese (Low et al., 1964)[40]
Boys	Modal skeletal age	
6.0 years	---	–1.1
6.5 years	–0.3	---
7.0 years	---	–1.4
8.0 years	---	–1.5
9.0 years	---	–1.5
10.0 years	---	–1.3
11.0 years	---	–1.2
Girls		
6.0 years	---	–0.8
6.5 years	0.0	---
7.0 years	---	–1.0
8.0 years	---	–1.1
9.0 years	---	–0.8
10.0 years	---	–0.6
11.0 years	---	–0.4

the present study was too small to provide reliable national estimates of their skeletal maturity, available information from previous studies on this aspect of development is included here for comparative purposes.

Sproul and Peritz[34] reported cross-sectional data from 162 upper-middle-class California children of Chinese ancestry. A hand-wrist skeletal age for each child was obtained by weighting the individual bone-specific skeletal ages by their first principal components. These area skeletal ages were standardized to a chronological age of 6.5 years after excluding late-appearing centers. The mean differences between the skeletal and chronological ages were 0.3 year in boys and zero in girls.

Cross-sectional data from 3,932 southern Chinese children in Hong Kong who were born between 1950 and 1956 (were 6-11 years of age) have been reported by Low et al.[40] (table G). These Greulich-Pyle assessments reported by Low et al. suggest a tendency to retardation that was more marked in boys than girls and tended to decrease with age in girls but not boys. These variations from standard atlas rates may reflect genetic differences between the samples of Low et al.[40] and Greulich and Pyle[6] in age-associated rates of skeletal maturation. Comparisons between the reports of Sproul and Peritz[34] and that of Low et al. for children of Chinese ancestry living in the United States and Hong Kong may suggest the extent to which environment can influence the rate of skeletal maturation.

Data have been reported from California children of Japanese ancestry and Japanese children in Japan. Greulich[41] reported cross-sectional data from a "representative sample" of American-born children of Japanese ancestry living in the San Francisco area of California. This sample included 13 to 48 children of each sex at each annual interval who had been born between 1945 and 1952. The mean Greulich-Pyle[42] skeletal ages were very close to the mean chronological ages. Cross-sectional data from 63 Japanese children of above-average socioeconomic status living in California have been reported by Sproul and Peritz.[34] After standardization to a chronological age of 6.5 years, mean skeletal ages were very close to the mean chronological ages in each sex. Sutow[43] reported cross-sectional data from normal Japanese children in Hiroshima who were born between 1940 and 1946 and examined within 1 month of a birthday. The sample size varied from 56 to 107 for each sex at each age. Standards were selected from these radiographs by a procedure similar to that used by Greulich and Pyle and these standards were assessed against the Greulich-Pyle Atlas in the manner described by Sutow and Ohwada.[44] These assessments show that, by comparison with the Greulich-Pyle standards, the "median" levels of skeletal maturity were low in these children, but there was no systematic sex difference nor change with increasing age in the amount of this retardation (table H). The skeletal maturity standards of Sugiura and Nakazawa[45] indicate that Japanese children, especially boys, are retarded skeletally by comparison with Greulich-Pyle standards. As suggested by Greulich,[41] it is reasonable to conclude that the differences between the skeletal maturity levels of children of Japanese ancestry in California and those in Japan are likely to be environmentally determined, although the possibility of selective migration cannot be excluded. The same pertains to the Chinese data that were described previously. Evidence that genetic factors may be involved in the differences between mean skeletal maturity levels of Japanese children and those of groups of white children in the United States has been provided by Kimura[46,47] who reported that skeletal age was more advanced in Japanese Americans 6-11 years old than in a control group of native Japanese children.

Other studies (variability).—Consideration of the magnitude of the standard deviations of the skeletal ages of white and Negro children in the 6-11 year age range in the present national study, within chronological age groups, and those from previous studies reviewed in earlier sections of this report provides some further insight into the comparability of the findings. Nevertheless, the national estimates of variability for all United States children from the present study for which radiographs were taken throughout the year (and not limited to ages

Table H. Modal skeletal age levels (Greulich-Pyle SA - CA, in years) at various chronological ages in American children of Japanese ancestry and in Japanese children

Sex and chronological age	Japanese ancestry-California		Japanese-Hiroshima	Japanese-Japan
	(Greulich, 1957)[41]	(Sproul and Peritz, 1971)[34]	(Sutow and Ohwada, 1953)[44]	(Suguira and Nakazawa, 1968)[45]
	Modal skeletal age			
Boys				
6.0 years...	−0.6	---	−1.5	---
6.5 years...	---	−0.3	---	2.0
7.0 years...	−0.4	---	−1.7	---
7.5 years...	---	---	---	2.0
8.0 years...	−0.7	---	−1.0	---
8.5 years...	---	---	---	1.5
9.0 years...	−0.4	---	−1.2	---
9.5 years...	---	---	---	1.5
10.0 years..	−0.2	---	−1.3	---
10.5 years..	---	---	---	1.25
11.0 years..	−0.4	---	−2.0	---
Girls				
6.0 years...	+0.3	---	−1.7	---
6.5 years...	---	+0.2	---	0.75
7.0 years...	−0.1	---	−0.7	---
7.5 years...	---	---	---	1.0
8.0 years...	−0.1	---	−1.2	---
8.5 years...	---	---	---	1.25
9.0 years...	+0.1	---	−1.3	---
9.5 years...	---	---	---	1.25
10.0 years..	+0.1	---	−1.0	---
10.5 years..	---	---	---	0.5
11.0 years..	+0.6	---	−1.0	---

near birthdays as in most of the previous studies) are generally within the range of variability reported in these previous studies and usually near the upper end of the distribution, as might be expected with the greater number of assessors in the national study and the fact that radiographs were taken throughout the year. The slightly larger standard deviations reported for Nebraska children by Fry[22] and for Philadelphia children by Malina[37] could reflect the fact that these radiographs were not taken systematically close to birthdays (table J). However, despite similar scheduling, those reported for Philadelphia children by Johnston[20] are generally smaller. The smaller standard deviations at most ages reported for Cleveland children by Simmons,[17] for Denver children by Hansman and Maresh,[48] and for Boston children by Bayley[19] presumably reflect the socioeconomic and ethnic homogeneity of their samples in addition to the scheduling of examinations close to birthdays. The reported data do not show sex-associated differences in the variability of skeletal age within chronological age groups.

Data from children outside the United States have shown that variability was comparatively low in the sample of Australian children of British ancestry studied by Roche,[30] but high among the sample of Danish children studied by Andersen[26] and the sample of Chinese children studied by Low et al.[40] (table K). Again, these differences could reflect variations between the studies in the scheduling of examinations. Kopczynska[31] reported standard deviations for skeletal ages in Polish children that were at about the center of the range of deviations reported in the previous studies among selected groups of United States white children. The data of Marshall et al.[39] shows a tendency to greater variability in Negro Jamaican boys than among Negro boys in the United States from the present study;. there was no corresponding tendency for girls.

Geographic Region

The mean regional differences in maturation, with few exceptions, tend to be small enough to be attributable to chance alone with the size and design of the sample used in the 1963-65 Health Examination Survey for these national estimates (i.e., they do not exceed the 95-percent confidence limits for such estimates). Boys 6-11 years of chronological age in the Northeast and

Table J. Standard deviations (in years) for skeletal age within chronological age groups for studies among U.S. children

Sex and chronological age	Chicago (Flory, 1936)[16]	Cleveland (Simmons, 1944)[17]	Denver (Hansman and Maresh, 1961)[48]	Boston (Bayley, 1962)[19]	Philadelphia (Johnston, 1962)[20]	Nebraska (Fry, 1966)[22]	Philadelphia (Malina, 1970)[37]		United States, 1963-65	
							White	Negro	White	Negro
	Standard deviation									
Boys										
6 years	1.09	0.76	---	0.78	---	0.74	1.2	1.4	0.96	0.90
7 years	1.24	0.74	---	0.84	0.72	0.80	1.0	1.5	0.96	1.08
8 years	1.08	0.76	0.8	0.90	0.82	1.06	1.0	1.4	1.00	0.84
9 years	1.07	0.75	---	0.92	1.06	1.32	1.2	1.2	0.95	0.88
10 years	0.99	0.82	---	0.95	0.94	1.45	1.1	1.3	0.85	0.86
11 years	1.02	0.84	---	0.87	0.79	1.20	1.2	1.4	1.09	1.14
Girls										
6 years	0.87	0.85	---	0.75	---	0.91	1.0	1.2	0.89	0.96
7 years	0.83	0.80	---	0.69	0.73	1.21	1.2	1.3	0.88	0.85
8 years	1.10	0.85	0.9	0.73	0.84	1.02	0.9	1.3	0.87	1.03
9 years	0.87	0.89	---	0.78	1.00	0.90	1.0	1.0	1.04	1.33
10 years	0.82	0.98	---	0.90	0.12	1.24	0.7	1.2	1.22	1.24
11 years	0.93	0.99	---	1.03	1.13	0.87	0.9	0.9	1.00	1.18

Table K. Standard deviation (years) for skeletal age within chronological age groups for studies among children of foreign countries

Sex and chronological age	Australian-British ancestry (Roche, 1967)[30]	Danish (Andersen, 1968)[26]	Chinese (Low et al., 1964)[40]	Jamaican (Marshall et al., 1970)[39]
Boys	Standard deviation			
6.0 years	0.5	---	0.8	---
7.0 years	0.5	0.9	0.9	---
7.5 years	---	---	---	0.7
8.0 years	0.7	1.0	1.1	---
8.5 years	---	---	---	1.7
9.0 years	0.8	1.0	1.3	---
9.5 years	---	---	---	1.5
10.0 years	0.8	1.4	1.3	---
10.5 years	---	---	---	1.3
11.0 years	0.8	1.1	1.2	---
Girls				
6.0 years	0.5	---	0.9	---
7.0 years	0.6	1.0	1.0	---
7.5 years	---	---	---	1.1
8.0 years	0.7	0.8	1.2	---
8.5 years	---	---	---	1.2
9.0 years	0.6	0.9	1.3	---
9.5 years	---	---	---	0.8
10.0 years	0.6	0.9	1.4	---
10.5 years	---	---	---	0.9
11.0 years	0.7	1.0	1.3	---

Midwest Regions of the United States generally tend to be more advanced in skeletal maturity than boys in the South or West, while girls in the West are less advanced skeletally than girls in the other three regions (table 2, figure 9).

Among boys at individual years of chronological age, the mean skeletal ages (hand-wrist) of those in the Northeast are more advanced (closer to their chronological age) at chronological ages 6, 8, 10, and 11 years than for boys in other areas of the country. At ages 7 and 9 years, boys from the Northeast lag slightly behind those in the Midwest in this respect. Only at 7 years for boys in the Midwest and Northwest and at 11 years in the Northeast are the mean regional differences large enough to be considered statistically significant. Boys of chronological ages 6, 7, and 11 years in the South and those of ages 8-10 in the West tend to be less mature skeletally than those from the other regions of the country.

Girls in the Northeast and Midwest are, on the average, more skeletally mature at chronological ages 6-9 years than those in the South and West. However, only at age 6 for girls in the Northeast and Midwest and at ages 7 and 9 years for those in the Northeast are the mean skeletal ages (hand-wrist) significantly higher (at the 5-percent probability level) than those for girls in other regions. Among older girls 10 and 11 years of age at their last birthday, mean regional differences in skeletal maturity are negligible.

When any effect of differences in age distribution for children 6-11 years of age among the four regions of the country is removed by an indirect age adjustment, both boys and girls in the Northeast are clearly more advanced and those in the Midwest slightly more advanced in skeletal maturity than those from the West and South (figure 10).

Girls tend to be more advanced in skeletal maturity (female equivalent values) than boys in each of the four regions of the country. The mean differences are greatest by 3 to 5 months (and large enough to be statistically significant at the 5-percent probability level) among older

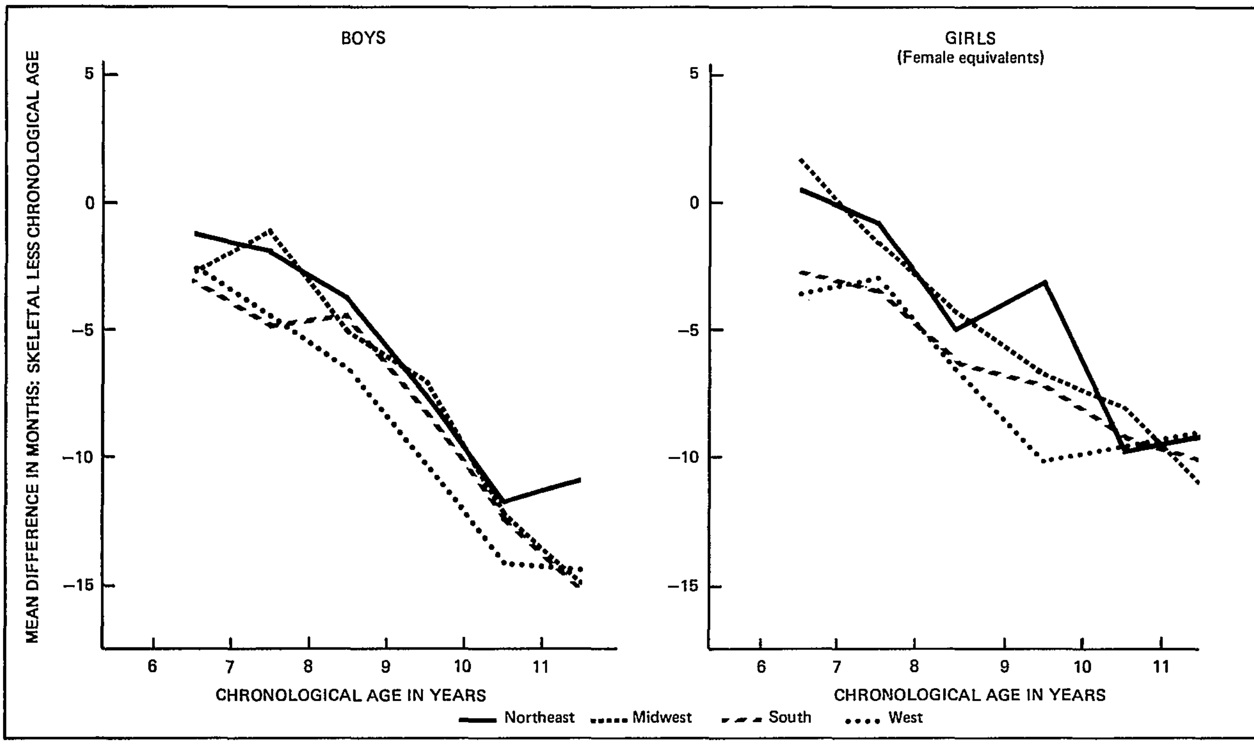

Figure 9. Mean difference in months between skeletal age (hand-wrist) and chronological age for boys and girls, by geographic region and chronological age in years: United States, 1963-65.

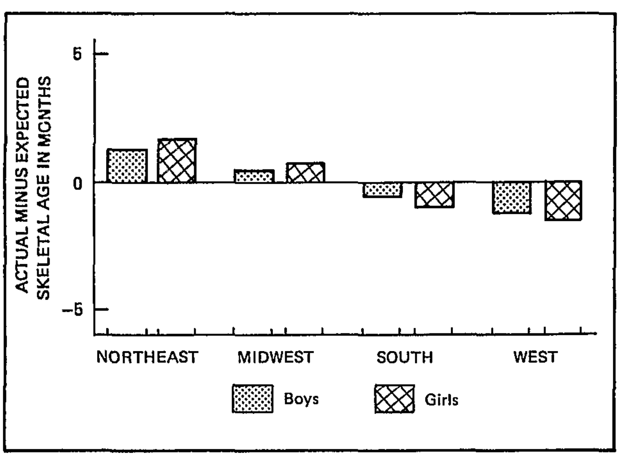

Figure 10. Difference between actual and expected mean skeletal age (hand-wrist) for boys and girls 6-11 years of chronological age, by geographic region: United States, 1963-65.

children aged 10 and 11 years in the Midwest, South, and West; among 9-year-olds in the Northeast; and among 6-year-olds in the Midwest. Few minor, nonsignificant exceptions did occur—at chronological age 8 years in the Northeast and South, 7 years in the Midwest, and 6 years in the West—where the mean skeletal ages (hand-wrist) of boys exceed those of girls, on the average, by 2 months or less.

Among both boys and girls in each of the four regions of the country, the greatest relative variation in skeletal maturity, in relation to the magnitude of the mean, is among the youngest children 6 years of age. Older children, 10 years of age among boys and 11 years of age among girls, are consistently the least variable in this aspect throughout the country. The relative variability in skeletal maturity among boys in each of the four regions decreases consistently with increasing chronological age from 6 to 10 years of age, then increases slightly among 11-year-olds. In contrast, no consistent regional pattern in relative variability by chronological age is evident among girls, except at the extremes—6 and 11 years—as noted above. Relatively more variability in skeletal maturity is present among younger boys than among girls 6-8 years of chronological age in each region of the country, and, among older boys than girls, at chronological age 11, except for those in the

South. At chronological age 10 years, boys are relatively less variable than girls in skeletal maturity.

When only white children aged 6-11 years are considered, the analysis by geographic regions shows that boys in the South and West and girls in the West tend to be somewhat less advanced skeletally than children in other regions. The regional pattern in skeletal development among Negro children is similar to that for white children, but the sample size is too small to provide reliable estimates in this detail for that segment of the population.

White children at each year of age across the 6-11 year range were generally less mature skeletally than Negro children in each of the four regions of the country (table 4). The pattern is somewhat more consistent among girls than boys. Only in the South (where the proportion of Negro children was about twice that in the other three regions at the time of this study) among younger boys 6-8 years of chronological age are the differences large enough to be considered statistically significant at the 5-percent probability level.

When the effect of the differences in the age distribution for white and Negro children in the four regions of the country is removed, the pattern of more advanced skeletal maturity than expected among both white and Negro boys and girls 6-11 years of age in the Northeast and Midwest and less advanced than expected among those in the South and West is clearly evident (figure 11). However, because of the relatively small size of the Negro population in the West, particularly, and in the Northeast and Midwest, the apparent white-Negro differences shown here among the regions are not statistically significant.

Other studies.—Only infrequently have geographic factors in relation to skeletal maturation been studied previously in circumstances that allow the separation of racial and socioeconomic factors. The only possibly revelant data come from previous uncoordinated studies of children living in different regions at different points in time. Sampling procedures differ among these studies, and comparability of the assessment techniques employed is unknown. In fact, it is possible that regional differences in this aspect of development that are not due to local variations in the incidence of illness, malnutrition, climate, or altitude may not exist. Geographic differences, within the United States among the 6- to 11-year-old children in this national study, in the prevalence of abnormal findings on survey examination—whether due to illness, malnutrition, or other causes—have been reported previously.[49] The prevalence of physical abnormalities among these children is significantly less among those in the West than in the other three regions of the country and slightly but not significantly higher among those in the Midwest than those in the Northeast or South. However, skeletal maturity levels in the present study are slightly higher among children in the

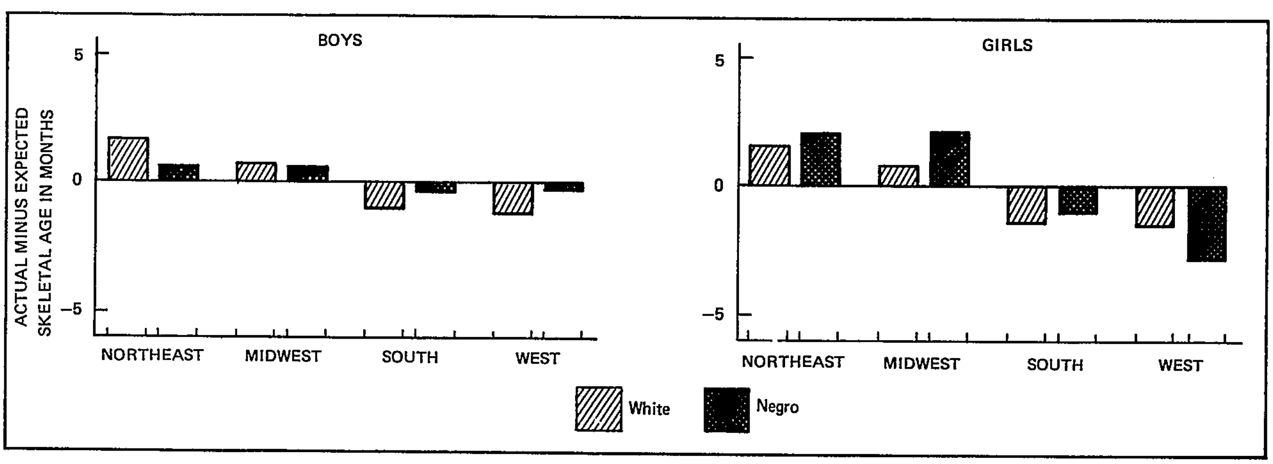

Figure 11. Difference between actual and expected mean skeletal age (hand-wrist) for white and Negro boys and girls 6-11 years of chronological age, by geographic region: United States, 1963-65.

Northeast and Midwest than in the West or South.

If secular changes have occurred in the skeletal maturation rates of U.S. children, presumably they reflect changes in many factors, including levels of nutrition and the incidence of illness or disability. Dearborn and Rothney[50] reported skeletal ages for 1,553 children aged 7 to 17 years (among whom 24 percent were of Italian ancestry) who were assessed using the 1934 unpublished Todd standards. These children were born about 1916 and were living in New England.[51] The data indicate consistent slight mean retardation of skeletal maturation (0.4 to 0.9 years) in comparison with the Greulich-Pyle standards, if it is assumed, as a reasonable approximation, that the 1934 and 1937 Todd standards were equivalent in level. These earlier findings are inconsistent with the present findings from representative samples of children in the Northeast.

The possible effects of climate are difficult to evaluate. It has been suggested that a tropical climate per se retards skeletal maturation,[52,53] but convincing evidence is lacking. There is doubt about the relevance of observations that heat promotes calcification *in vitro* and in chicken eggs.[54,55] Other studies of experimental animals have involved extreme environmental temperature differences.[56-59]

Important observations have been made by Nissen and Riesen,[60] who kept three chimpanzees almost completely in the dark from birth to ages ranging from 7 to 33 months. A fourth animal was deprived of light from 8 to 24 months. There were no differences between them and controls in either food intake or the amount of body movement, but the onset of ossification was delayed in the animals deprived of light.

Others have analyzed data from children, but there is a lack of agreement among these investigators. Sawtell,[61] in a study of 250 children found no tendency for the onset of ossification of carpals to occur during any particular season. However, in "normal" southwestern Ohio children aged 1-5 years, there was a tendency for the onset of ossification to occur between February and August rather than in the remainder of the year,[62] and onset of ossification was most common in the summer and least common in the winter in the malnourished Florida children.[63]

In the present national study, the skeletal maturation levels of children in the South and West are slightly lower than for children from the other two regions. However, while the climate in the South is generally warmer, that in the West covers the entire range of temperatures in this country. Hence, neither illness, malnutrition, other recorded conditions, nor climate seems to explain adequately the slight geographic differences in skeletal maturity levels of U.S. children found in the present study. The broad regions into which the United States had been divided for administrative purposes are so heterogeneous they may have obliterated local variations in skeletal maturity levels.

Urban-Rural

In some countries, urban and rural populations are sharply contrasted socioeconomically and, in some cases, genetically also. In such circumstances, there may be real urban-rural differences in skeletal maturity levels.[64-71] There were no consistent patterns of skeletal maturity differences among children in this national study that could be related to urban-rural factors or to the size of urban communities (table 6).

Girls in both urban and rural areas of the United States are generally more mature skeletally (female equivalent values) than boys of chronological age 6-11 years. The sex differences in mean skeletal age (hand-wrist) were largest—3 to 4 months—among the older children who were 10 and 11 years of age at their last birthday. This implies a relative lack of differences between urban and rural areas of the United States in the genetic and environmental factors that influence the rate of skeletal maturation.

Socioeconomic Factors

There was only a slight association between socioeconomic status as measured by family income and the level of skeletal maturity of U.S. children as determined in the present national study.

Among boys of chronological age 7 through 9 years, those most advanced in skeletal age (hand-wrist) were from families in the highest annual income level—$10,000 and more—while the mean skeletal age values were lowest among those from families with annual income of less than $5,000 (table 3 and figure 12). Among the oldest boys (age 11 years at their last birthday), those from the lowest income level tended to be the most advanced in skeletal maturity, while those from the middle income bracket were least advanced in skeletal maturity. The differences between these extreme mean values of skeletal age—ranging from 0.2 months at 8 years to 3.6 months at 9 years—were too small to be of statistical significance considering the size and design of the sample used in the survey.

Girls aged 6-11 years from families in the higher income levels of $5,000 or more per year were slightly but consistently more advanced in skeletal maturity than other girls. Only at ages 7-9 years were those in the lowest income bracket (less than $5,000) the least advanced in this aspect of development. However, all differences between the extreme mean values of skeletal age were negligible (less than 1 month), except at age 9 years when the girls from the lowest income level families were significantly more retarded (mean difference of 4 months) in skeletal maturity than those from families with income of $10,000 or more.

If children in families from the extremes of the income range are considered—those in families with annual income less than $3,000 and those of $15,000 or more—skeletal maturity is consistently least advanced among those in the lowest income bracket across the chronological age range 6-11 years among both boys and girls when all races are combined.

When the effect of differences in the age distribution among the various income level groups is removed, boys and girls of 6-11 years in middle and upper income bracket families are slightly more advanced in skeletal maturity than expected, and those at the lowest income level are least advanced in this respect, though the mean differences are insignificant (figure 13).

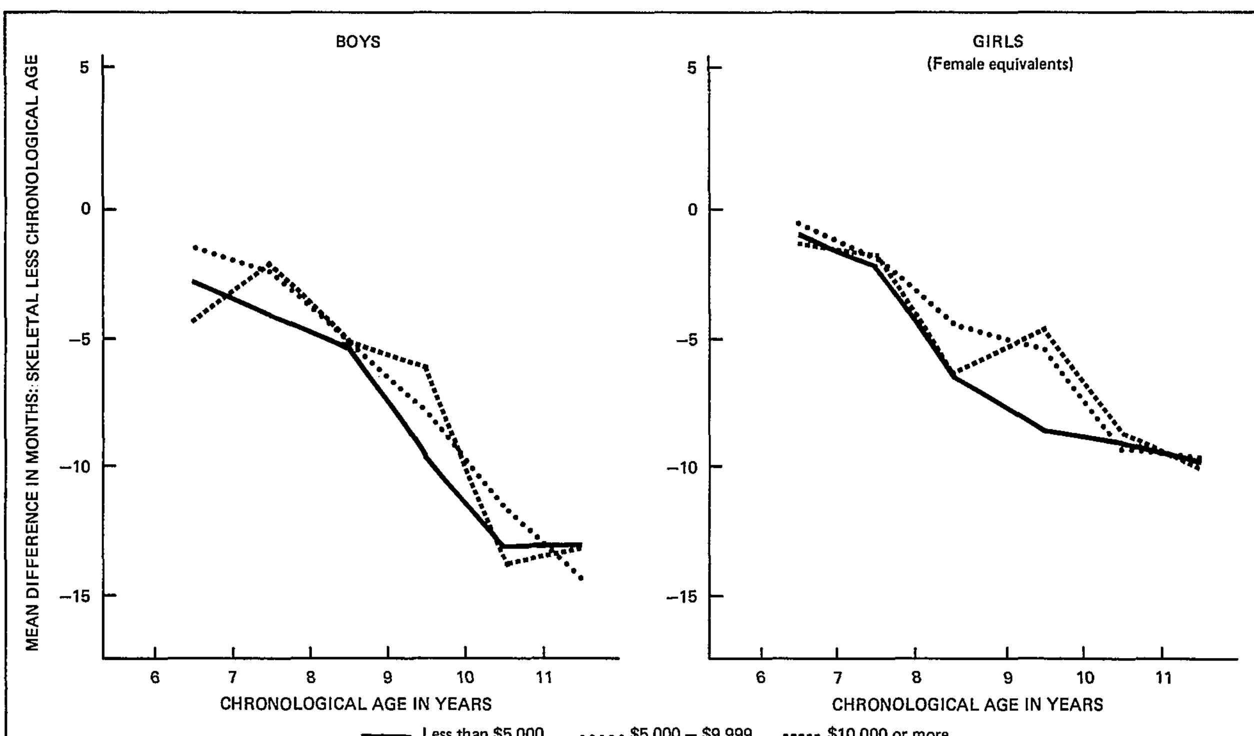

Figure 12. Mean difference in months between skeletal age (hand-wrist) and chronological age for boys and girls, by annual family income and chronological age in years: United States, 1963-65.

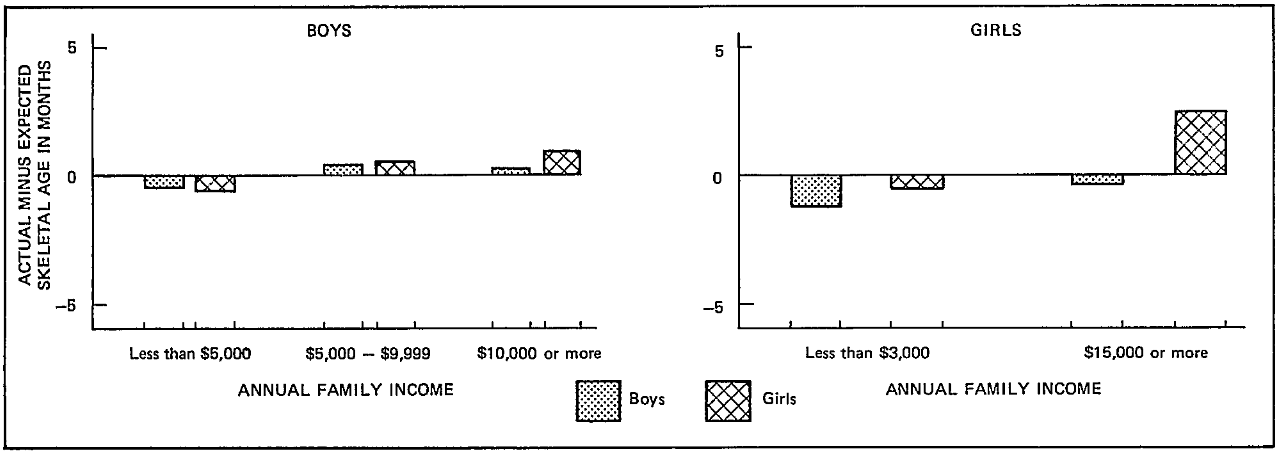

Figure 13. Difference between actual and expected mean skeletal age (hand-wrist) for boys and girls 6-11 years of chronological age, by annual family income: United States, 1963-65.

Boys tend to be consistently less advanced in skeletal maturity than girls of corresponding chronological age across all income levels, with minor exceptions at chronological age 8. Only among the oldest children, those 10 and 11 years of age, were the sex differences in mean skeletal age (hand-wrist) within each income level large enough (approximately 4 months or more) to be statistically significant.

The pattern of variation in skeletal maturity among boys and girls across the three income levels is inconsistent also. Boys of chronological ages 8 and 11 years are more variable in skeletal maturity than girls of the same age in each of the three income groups, but boys are less variable at 9 and 10 years.

Among white boys and girls, there is evidence of a positive association of skeletal maturity with family income. Mean skeletal age (hand-wrist) increases slightly but consistently with the income level of the family. No such consistent pattern was present among Negro boys or girls.

When racial differences in skeletal maturity among white and Negro children are considered in relation to family income level, white children aged 6-11 years consistently had lower mean skeletal ages than Negro children of comparable chronological age, with minor exceptions at 10 years for boys and 8 years for girls among those whose family income was less than $5,000. Among children from families in the intermediate income brackets ($5,000-$9,999 per year), white boys tended to be more advanced in skeletal maturity than Negro boys at chronological ages 8-11, but younger white boys and white girls of 6 and 8-10 years were less advanced in this respect than their respective Negro counterparts (table 5). These patterns are clearly evident in figure 14 where the effect of differences in the age distribution of the Negro and white children within these income levels has been removed. The number of Negro children in families with annual income of $10,000 or more at the time of this study was too small to obtain reliable national estimates of skeletal maturity for them.

Similar to the findings with respect to family income, there is a lack of a consistent relationship between skeletal maturity of children and the formal education of their fathers (head of household). This is evident in table 7, and would be expected because of the high level of association between income and education ($r = .58$).[68]

Other studies.—Skeletal maturity levels of children from different socioeconomic backgrounds have been reported for subgroups of the population in the United States and other countries. These previous findings will be considered in relation to those from the present study.

Sproul and Peritz[34] reported data from 162 California children of Chinese ancestry. These children were above average socioeconomically for the San Francisco area and, presumably, would be for Hong Kong also. Low et al.[40] reported Greulich-Pyle skeletal ages from a large

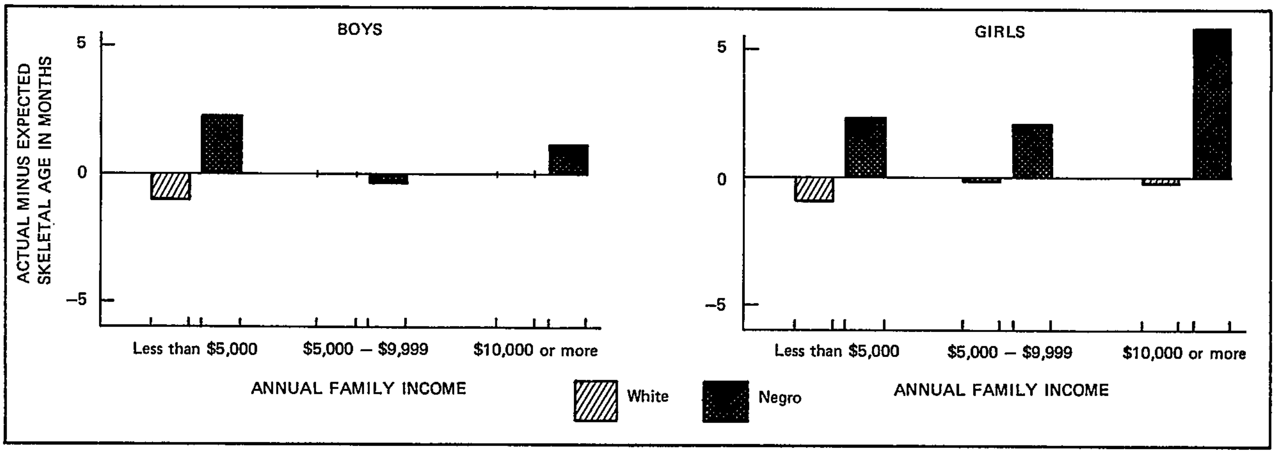

Figure 14. Difference between actual and expected mean skeletal age (hand-wrist) for white and Negro boys and girls 6-11 years of chronological age, by annual family income: United States, 1963-65.

sample of 3,932 Hong Kong children who were grouped into high, middle, and low socioeconomic groups (table L). This grouping was made using a combination of parent's education, parent's occupation, total family income, and housing.[69] Population genetic differences between the California children and the three groups of Hong Kong children cannot be excluded with certainty but are not considered to have been an important factor.[a] In contrast to the findings from the present national study where essentially an association was not found between skeletal maturity of children and the

[a]Lee, personal communication, 1972.

Table L. Mean skeletal ages (in years) for children of Chinese ancestry at various socioeconomic levels

Sex and chronological age	Chinese ancestry-California (Sproul and Peritz, 1971)[34]	Southern Chinese in Hong Kong (Low et al., 1964)[40]		
	Very high status	High status	Middle status	Low status
Total number of children	162	768	1,050	2,114
	Mean skeletal age			
Boys				
6.0 years	---	5.4	5.0	5.1
6.5 years	6.2	---	---	---
7.0 years	---	5.8	5.7	5.6
8.0 years	---	6.7	6.6	6.3
9.0 years	---	8.0	7.6	7.4
10.0 years	---	9.2	8.8	8.4
11.0 years	---	10.5	9.8	9.6
Girls				
6.0 years	---	5.8	5.4	5.3
6.5 years	6.5	---	---	---
7.0 years	---	6.2	6.0	5.8
8.0 years	---	7.4	7.2	6.5
9.0 years	---	9.1	8.3	7.9
10.0 years	---	9.7	10.0	9.2
11.0 years	---	11.3	11.0	10.4

single socioeconomic factor of family income, the skeletal maturity level among these Chinese children was generally more advanced among those of high, as opposed to low, socioeconomic status. However, the latter mean differences are small despite the large range of socioeconomic status between the groups compared. These comparatively small differences are in agreement with the observations of Grande Covián and Rof Carballo.[70]

Kopczynska[31] reported data from upper and lower socioeconomic class Polish children (total N = 280) that showed a positive association between socioeconomic status and the level of skeletal maturity. These findings are in agreement with those of DeWijn[71] for Dutch children. Andersen[26] reported a marked association of occupation of father, and a lesser association of family income with skeletal maturity level. In her data, crowding of apartments was associated with skeletal retardation in the lower but not the upper socioeconomic groups. Andersen presented her findings as the percentages skeletally advanced or retarded but did not report the differences in skeletal age years. Consequently, more precise comparisons cannot be made with these data.

Comparisons between boys aged 6.5 to 8.5 years of very low (N = 80) or high (N = 20) socioeconomic status in a suburb of Tunis show a median difference in skeletal maturity (Greulich-Pyle) between the two groups of approximately 1 year as reported by Young et al.[72] These findings are in agreement with those of Rea[73] for Nigerian preschool children. However, Neyzi et al.,[74] using data from 3,000 urban Turkish children of moderately different socioeconomic levels, found only slight associations with skeletal maturity levels.

Acheson and Hewitt[75] related socioeconomic status based on father's occupation to skeletal maturity in preschool English children. There was a slight tendency for skeletal maturity to be more advanced in boys of upper socioeconomic status (about 0.2 year) but no such tendency in the girls.

Asiel[27] reported only a slight socioeconomic influence on the level of skeletal maturity in Belgian boys aged 5 to 9 years, whether assessments were made by the Greulich-Pyle or the Tanner-Whitehouse method.

BONE-SPECIFIC SKELETAL AGE FINDINGS

In the Greulich-Pyle method of assessment, the skeletal maturity of the hand-wrist assigned to an individual child is based usually on the average of the ages assigned those of his 31 hand-wrist bones that are radio-opaque but not classified as adult. Some investigators use the median; others assign an age to the whole area without recording separate skeletal ages. In this report, as in the previous one,[1] the common practice of using the average has been followed. The order of onset of maturation and the rate of maturation of individual bones vary considerably among individual children. For children in the age range of concern in this study, 6-11 years, the majority of the 31 hand-wrist bones have become radio-opaque, but their maturation is not complete. There are only six bones in which ossification is normally delayed until age 6 years or later. During the age range 6-11 years, ossification begins typically in the distal ulnar epiphysis, trapezium, trapezoid, and adductor sesamoid in boys and in the pisiform in each sex. Ossification of the flexor sesamoid is usually delayed until the twelfth year or later.

Race

White children in this country generally tend to be less advanced than Negro children in the skeletal maturity of the individual hand-wrist bones, though the pattern is not as consistent as that for overall skeletal age (hand-wrist).

For three-fifths (19) of the 31 bones, the mean skeletal age of white children lags consistently behind that for Negro children of corresponding chronological age, with only minor exceptions (table 9). This pattern (mean differences of 2-4 months, which are statistically significant at the 5-percent probability level) is generally consistent for both boys and girls across the 6-11 year age range for seven of the bones—the hamate, lunate, trapezium, metacarpal I, and metacarpals III-V. For seven other bones—the radius, ulna, capitate, triquetral, scaphoid, trapezoid, and metacarpal II—the only exception to this pattern is among 10-year-old boys. For children of chronological ages 6-11 years, the mean white-Negro differences in skeletal age of these seven bones are also large enough to be statistically significant (differences of 2-4 months) except for the ulna among boys. The mean skeletal age for the adductor sesamoid also is significantly more advanced among Negro than white boys and girls, as are the mean skeletal ages for the distal phalanges III-V among boys, but the patterns at separate years of chronological age are less consistent than for the 14 bones described previously. For the proximal phalanx I among both boys and girls and the distal phalanges III-V among girls, the mean racial differences are negligible (not significant at the 5-percent probability) and are less consistent over the age range in this study.

The racial differentials in mean skeletal maturity levels are less consistent in the remaining 12 bones. Proximal phalanges II-V and the middle phalanx II were slightly more advanced in skeletal maturity among white than Negro children, but this pattern was not consistent across the age range for either sex. The pattern of racial differences in skeletal maturity is even less consistent with respect to the middle phalanges III-V and the distal phalanx I, and differs between boys and girls. These latter four bones were slightly but not significantly more mature among white than Negro girls. Among white and Negro boys, the mean skeletal ages of the middle phalanges III-V were identical for all ages combined, while in the distal phalanx I, white boys lagged slightly behind Negro boys in skeletal age, on the average. In the later ossifying pisiform and flexor sesamoid, white boys are slightly more skeletally mature than Negro boys, but this racial pattern is reversed among girls. The mean skeletal age for the distal phalanx II was identical for white and Negro girls, while white boys were somewhat less mature than Negro boys with respect to this bone.

If Todd's[18] theory of the evenly maturing skeleton were applicable, one would expect mean skeletal ages (hand-wrist) to be fairly evenly distributed across the 31 individual bones in white and Negro children. The extent of lack of agreement with this theory among the 6- to 11-year-old United States children is clearly evident in figure 15, which shows, for the total chronological age range (6-11 years), the mean differences between skeletal age and chronological age for white and Negro boys and girls for 28 of the individual bones. The pisiform and the two sesamoids have been omitted because they are ossified only in the more mature children.

Geographic Region

The regional pattern found among United States children 6-11 years of chronological age in the present national study (i.e., somewhat more advanced skeletal age (hand-wrist) among those children in the Northeast and Midwest than those in the South and West) is evident also in the mean skeletal age values for 30 of the 31 hand-wrist bones (table 10). The only exception is for the adductor sesamoid, where the children from the West and South are slightly, but not significantly, more advanced than those from the Midwest.

Income

Among both boys and girls, those from the lower income level families (with annual income of less than $5,000) tended to be somewhat less advanced in the skeletal maturity of individual hand-wrist bones than those from the higher income level families (with annual income of $7,000 or more). This is similar to the findings with respect to their skeletal age (hand-wrist).

The mean skeletal age findings for six of the individual hand-wrist bones (representative of the groups of principal maturation patterns shown for all but the later ossifying bones) among these children are shown by the income level of their families in tables 11 and M. Skeletal age for these typical bones tends to be more advanced (or less retarded) relative to chronological age among children in the higher than lower income level families. This effect was present in each sex and was somewhat more marked and consistent in the third and fourth proximal phalanges and the fifth middle phalanx, indicating that the maturation of these bones might be particularly sensitive to environmental influences.

Other studies.—Bone-specific skeletal age findings by race or ethnic background from some previous studies among groups of children in the United States and other countries are available for comparison with the present findings for United States children.

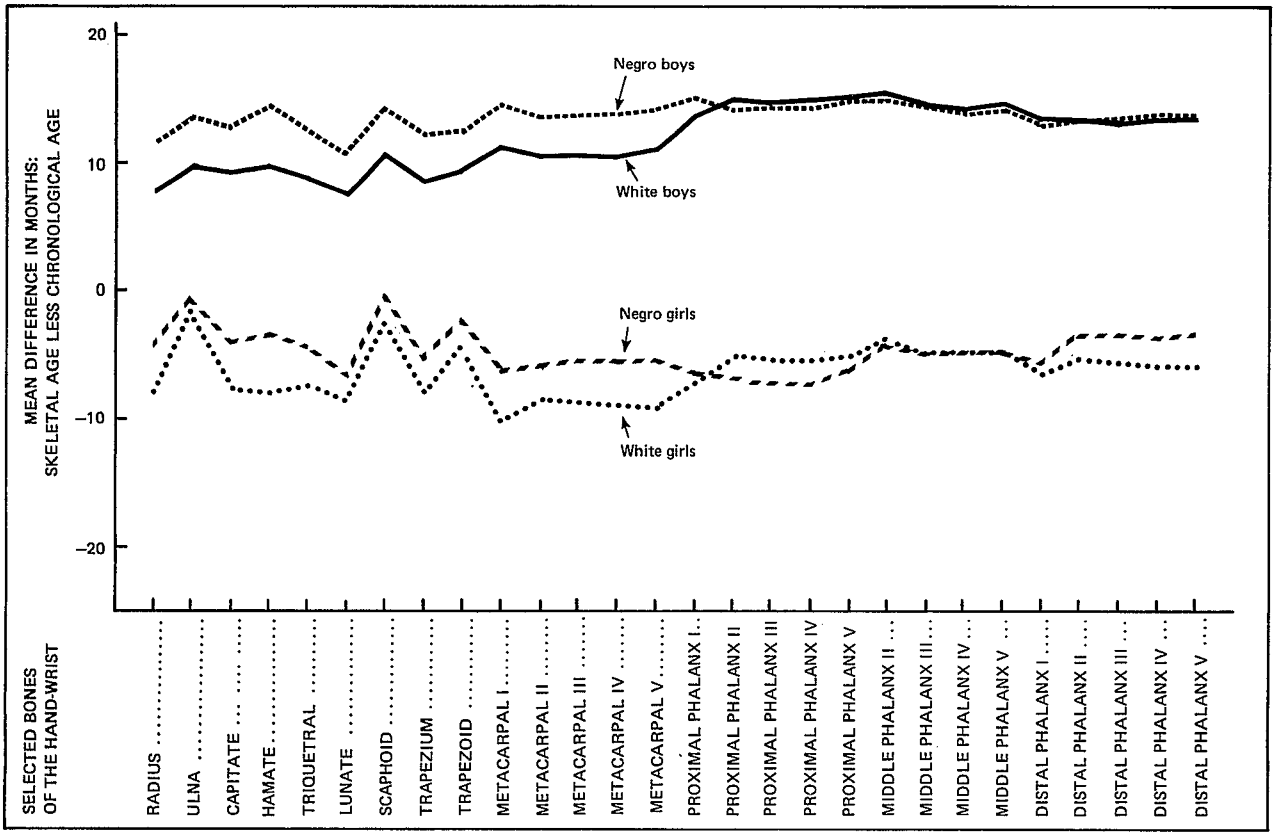

Figure 15. Mean white-Negro differences in the deviation of bone-specific skeletal ages of chronological ages of boys and girls: United States, 1963-65.

Table M. Mean differences between skeletal and chronological ages in years among income groups.

Sex and bone	Income					
	Less than $3,000	$3,000-$4,999	$5,000-$6,999	$7,000-$9,999	$10,000-$14,999	$15,000 or more
Boys	Mean difference					
Triquetral	−0.6	0.9	0.7	−0.8	0.1	0.5
Metacarpal III	−1.0	0.6	0.7	−0.1	−0.2	0.1
Metacarpal V	−1.2	0.7	0.6	0.1	−0.4	0.3
Proximal phalanx III	−2.4	−0.2	0.7	1.1	0.6	1.2
Proximal phalanx IV	−2.5	−0.2	0.7	1.0	0.8	1.4
Middle V	−2.2	0.2	0.9	0.9	−0.2	0.1
Girls						
Triquetral	−0.1	−0.5	−0.5	0.8	−0.6	2.1
Metacarpal III	−0.5	−0.3	−0.4	1.0	−0.6	3.0
Metacarpal V	−0.4	−0.3	−0.5	1.2	−0.6	2.8
Proximal phalanx III	−1.2	−1.1	−0.6	2.2	0.1	2.6
Proximal phalanx IV	−1.3	−1.0	−0.5	2.2	0.1	2.6
Middle V	−1.4	−1.3	−0.7	2.6	−0.2	4.0

Roche[7] reported bone-specific skeletal ages for 4-year-old children of British ancestry living in Melbourne, Australia. There was a definite tendency in the boys and a slight tendency in the girls for the rays of the hand to be less mature as those progressively closer to the ulnar side were considered. (A ray of the hand-wrist consists of a metacarpal with its associated phalanges, e.g., metacarpal III, proximal phalanx III, middle phalanx III, and distal phalanx III.) These variations could have been due to real differences in these children, limitations in the standardization group used to construct the Greulich-Pyle standards, or errors made during assessment.

Malina[36,76] reported Tanner-Whitehouse skeletal age scores for specific bones in white and Negro Philadelphia children aged 6 to 11 years. These individual bone scores cannot be converted to skeletal ages, but they can be used to compare the levels in white and Negro children of the same sex. The radius and ulna were more advanced in the Negro boys than in the white boys at almost all ages and, in general, the carpals were more advanced at ages 6 to 9 years. At most ages, however, the proximal phalanges were less advanced in the Negro boys than the white boys. Almost all bones tended to be more advanced in the Negro girls than in the white girls except the ulna at younger ages.

Peritz and Sproul,[77] using the racial samples described earlier,[34] reported mean skeletal ages (Greulich-Pyle) for the triquetral, lunate, proximal phalanx III, and distal phalanx III, after each had been standardized to a chronological age of 6.5 years (table N). In the boys, the proximal phalanx III or distal phalanx III tended to be the most mature of these bones; and in each group of girls, the triquetral tended to be the most mature. Some differences between mean skeletal ages were considerable, possibly due to the small number in the groups studied; e.g., in the Japanese boys the difference between the mean ages for the lunate and proximal phalanx III was 1.4 years.

Table N. Mean skeletal ages for selected bones, standardized to a chronological age of 6.5 years (Sproul and Peritz, 1971)[34]

Sex and race	Bone			
	Triquetral	Lunate	Proximal phalanx III	Distal phalanx III
	Mean skeletal age			
Boys				
White	6.5	5.9	6.9	6.6
Negro	6.7	6.2	6.7	6.9
Chinese	5.9	5.6	6.4	6.5
Japanese	6.3	5.4	6.8	6.2
Girls				
White	6.8	6.1	6.5	6.4
Negro	7.3	6.5	6.0	6.4
Chinese	6.7	6.2	6.3	6.1
Japanese	7.0	6.1	6.9	6.5

Range of Bone-Specific Skeletal Ages

Many previous studies reported in the literature claim that illness or malnutrition has differential effects between bones on ages at onset of ossification or rates of later maturation. Findings from this present national survey with respect to the consistency and variability in the range of bone-specific skeletal ages across racial, regional, and economic subgroups among the United States children of chronological ages 6-11 years provides normative data that can be used to further assess the effect of such factors as illness or malnutrition on skeletal development.

Race.—Medians and quartile points in the distribution of the range from the highest to the lowest bone-specific skeletal ages within the hand-wrists of individual white and Negro boys and girls by single years of chronological age from 6-11 years are shown in table 12. The data for each sex are based on male skeletal age standards. In interpreting these data, it should be recalled that some "bones" were not assessed in these children because, as noted earlier, skeletal age in years cannot be assigned to bones that are not yet radio-opaque or to those bones that have reached adult levels of maturity.

In both white and Negro boys, the median ranges decrease consistently with advancing chronological ages from 29 months among both groups at age 6 years to 19 months among white boys and 21 months among Negro boys at age 11 years. In contrast, for white and Negro girls, the median range was greatest at age 6 (27 months for white girls, 28 for Negro girls) but lowest at 8 and 9 years (about 22 months for both groups) and increased slightly to 24 months for both groups at 10 and 11 years. In general, there were corresponding trends at the 75th and 25th percentile levels. The greatest variability (as measured by the interquartile range P_{75}-P_{25}) in the range of bone-specific skeletal ages for white and Negro boys was among the younger, 6-9 years of age, and the least variability among the older boys, 10 and 11 years of chronological age. The sex differences in both white and Negro children in the age-related patterns of change in these ranges probably reflect the differential timing of pubescent changes between sexes.

When the white and Negro groups were compared, the differences between the median ranges tended to be slightly greater among younger white than Negro boys at ages 6-8 years but lower at ages 9-11 years. Only at age 9 years was the racial difference in median range among boys substantial. In contrast, among girls, median ranges were slightly but consistently greater among the Negro than white groups, with a negligible exception at chronological age 9 years.

Region.—No significant pattern of regional differences in the median ranges for bone-specific skeletal ages was found among United States boys or girls (table 13). Boys in the West showed the highest median values at ages 6, 8, and 9 years but the lowest at age 10 years. Among girls of 8-11 years, median range values were greatest for those in the Midwest, and at 6, 9, and 10 years were least for those in the West. Other regional differences in these median ranges were less inconsistent. Presumably, this reflects the heterogeneity in the populations included in the broad regional groupings into which the country was divided for the purposes of this national study.

The variability in the range values tended to be greatest among younger boys (7 years of age in the Midwest, South, and West and 8 years in the Northeast) and least among older boys (10 years of age in the Northeast and West and 11 years in the Midwest and South). The regional pattern in the variability in these range values among girls was less consistent.

Socioeconomic.—Possible socioeconomic influences on the range of bone-specific skeletal ages within individuals were analyzed in relation to family income. The findings are not easily interpreted. The median ranges tended to be greater in the middle income group ($5,000-$9,000) than in either the higher or the lower income groups, but this was true only at ages 6, 8, 10, and 11 years for boys and 6-9 years for girls (table 14). In general, the present data with respect to income-related differentials do not demonstrate any definite effect of this aspect of socioeconomic status on the range of skeletal maturity within the hand-wrists of United States children 6-11 years.

ONSET OF OSSIFICATION FINDINGS

Race

During ages 6-11 years, ossification usually begins in the distal ulnar epiphysis, trapezium, trapezoid, and pisiform in boys and in the pisiform and adductor sesamoid in girls.

The differences in median ages of onset of ossification between white and Negro children in the United States as estimated from the present Health Examination Survey are small and irregular in direction with the exception of the trapezium in the boys, for which onset of ossification (median age) was 1.5 years earlier in the Negro group than in the white group (table 15). This may indicate that the modal *order* of onset of ossification differs between these two groups, but this finding needs confirmation because the median age for Negro boys (4.9 years) is below the chronological age range of the present study.

Other studies.—The data for white United States children in table O are based on three types of modal ages: (1) median age at onset of ossification, (2) the mean age at onset of ossification, and (3) the estimated age when the center was ossified in 50 percent of the children. The children in these samples were predominantly of Northeastern European ancestry and of middle, or slightly above middle, socioeconomic status.

Harding[80] reported mixed longitudinal data from white Boston children born between 1930 and 1939 and examined near each birthday. The sample size varied from 63 to 67 at each age in each sex. Baldwin et al.[78] obtained mixed longitudinal data from upper-middle-class white children in Iowa City who were born between

Table O. Modal ages (in years) for onset of ossification in selected bones in U.S. white children

Sex and bone	Modal age and reference					
Boys						
Distal ulna	6.7,[34]	7.1,[78,79]	7.2,[80]	7.4,[81]	7.4,[6]	7.2[82]
Trapezium	5.9,[16,34,79]	6.2,[78,80]	6.3,[81]	6.2[82]		
Trapezoid	6.0,[78]	6.1,[16,80]	6.2,[79]	6.4,[34]	6.8,[81]	6.2[82]
Pisiform	11.0,[80]	11.2,[78]	11.7[81]			
Girls						
Pisiform	8.4,[80]	8.6[81]	9.0,[16]	9.7[78]		
Adductor sesamoid	10.7,[79]	11.3[81]				

1901 and 1928. There were from 28 to 49 children of each sex in each annual interval. Mixed longitudinal data from middle-class white children in Denver were reported by Hansman.[81] These children were born between 1915 and 1964, but most of the radiographs were taken after 1947. Sample size varied from 39 to 57 for each 6-month age interval in each sex.[23] A mixed longitudinal study of white Chicago children of above average socioeconomic status, born between 1911 and 1923, was reported by Flory.[16] These children were radiographed within 2 weeks of a birthday. Radiographs were available for 100 children of each sex at each age, except at 6 and 7 years when at least 80 radiographs were available. Garn et al.[79] reported mixed longitudinal data from middle socioeconomic class white children in southwestern Ohio born between 1929 and 1966. These children were radiographed within 1 month of each birthday and half-birthday. The sample size was about 180 for each sex in each 6-month interval. Sproul and Peritz[34] obtained cross-sectional data from children of above-average socioeconomic status living in or near Oakland, California. The sample size for both sexes combined was approximately 25 to 60 children at each annual interval from 6 through 8 years, with a further group of similar size examined at 9 years or over. The children were the 5 percent of the total sample nearest to the corresponding medians for stature.

In general, these data (table O) show that the onset of ossification, during the age range considered, tended to be later in the Denver children[81] than in children in Illinois, Ohio, or Massachusetts.[16,79,80] These differences are unlikely to be due to racial or socioeconomic factors, and they are not indicative of a secular trend.

In a review of data from children of European ancestry living outside the United States, the emphasis will be on those countries from which large numbers of immigrants have come to the United States. Sempé[83] reported median ages for the onset of ossification of the adductor sesamoid and pisiform in French children, generally of middle socioeconomic status, living in Paris (table P). These children were born in 1953 and radiographed close to birthdays and half-birthdays. Skubiszewska[84] used cross-sectional data from 273 Warsaw children aged 7 to 14 years. The modal ages for these children are similar to those reported for United States white children of middle socioeconomic status (tables 5, O, and P).

Comparisons between modal ages for the onset of ossification in Negro children living in the United States and Negro children living in Africa (table Q) are not easily interpreted. It is

Table P. Modal ages (in years) for onset of ossification in children of European ancestry living in Europe

Sex and bone	French children in Paris (Sempé, 1970)[83]	Polish children in Warsaw (Skubiszewska, 1964)[84]
	Modal age	
Boys		
Pisiform	11.0	---
Girls		
Pisiform	9.0	---
Adductor sesamoid	11.0	10.7

Table Q. Modal ages (years) for onset of ossification of selected bones in Negro children living inside and outside the United States

Sex and bone	Ten-State Nutrition Survey (Garn et al., 1972)[82]	California (Sproul and Peritz, 1971)[34]	Ovoloff children in Dakar, Senegal (Massé and Hunt, 1963)[86]	Ovoloff children in Dakar, Senegal (Michaut-Barthod, 1971)[87]	Dakar, Senegal (Massé, 1969)[88]	United States 1963-65
	Modal age					
Boys						
Distal ulna	6.7	6.6	---	---	---	7.0
Trapezium	5.8	6.1	---	---	6.7	4.9
Trapezoid	5.7	6.3	---	---	6.7	6.1
Pisiform	---	---	---	12.7	---	---
Girls						
Pisiform	---	---	10.5	11.8	10.5	8.9
Adductor sesamoid	---	---	12.5	---	---	10.7

impossible to identify groups of Negro children, in the United States or Africa, who belong to the same relatively homogeneous genetic pool. The data considered for Negro children in Africa relate to the West Coast, from which large numbers of slaves were imported into the United States.[85] However, it is unlikely that the present United States Negro population is representative of the original slaves, or that the slaves were representative of the African populations from which they were taken.

The data of Garn et al.[82] were obtained from a large sample of children included in the Ten-State Nutrition Survey. The data of Sproul and Peritz[34] were from California Negro children who were above average socioeconomically. The sample size for both sexes combined was approximately 18 for each annual interval; a group of similar size was examined at age 9 years or over. These children were the 5 percent of the total sample who were nearest to the corresponding medians in stature. Massé and Hunt[86] reported cross-sectional data from Ovoloff girls living in Dakar, Senegal. The total sample included 100 children, both sexes combined, examined near birthdays. They did not report how many of these children were girls. Michaut-Barthod[87] analyzed 628 radiographs of children of Ovoloff ethnic origin living in Dakar. Most of the children were radiographed three times near birthdays or half-birthdays. All were more than 11 years old at their first radiograph, but the data are useful for comparative purposes. The number of radiographs available was about 40 for each sex at each 6-month interval. These children were of low socioeconomic status even by local standards. Massé[88] obtained data from a representative sample of 100 Dakar children for each year of age of each sex.

Comparisons of these sets of data with those from the present survey show that onset of ossification tends to occur considerably earlier in United States Negro children than those living in Africa. The findings from the present national survey are in fair agreement with those from a small sample of California Negro children.[34]

The importance of genetic factors in determining age at onset of ossification is shown also by numerous reports that, at younger ages than those included in the present survey, Negro infants and children are more advanced than whites in this respect.

Sproul and Peritz[34] reported data from a cross-sectional study of upper-middle-class children of Chinese ancestry living in the San Francisco area (table R). Most, but not all, of these families came from the Kwangtung Province near Hong Kong.[b] The sample size, for both sexes combined, varied from 22 to 25 for each annual interval from 6 through 8 years. An additional 15 children were aged 9 years or over. Data for Hong Kong children[89] were obtained from a cross-sectional study of children of low socioeconomic status. The number in each an-

[b]Lee, personal communication, 1972.

Table R. Modal ages (in years) for onset of ossification of selected bones in children of Chinese ancestry living inside and outside the United States

Sex and bone	Chinese ancestry-California (Sproul and Peritz, 1971)[34]	Southern Chinese in Hong Kong (Lee et al., 1968)[89]
	Modal age	
Boys		
Scaphoid	6.4	7.2
Distal ulna . . .	8.1	8.7
Trapezium . . .	5.8	6.7
Trapezoid . . .	6.0	6.9
Girls		
Distal ulna . . .	6.7	7.8

Table S. Modal ages (in years) for onset of ossification of selected bones in children of Japanese ancestry living inside or outside the United States

Sex and bone	Japanese ancestry-California (Sproul and Peritz, 1971)[34]	Japanese-Hiroshima (Sutow, 1953)[43]
Boys	Modal age	
Scaphoid	7.2	7.1
Distal ulna	8.2	8.4
Trapezium	5.5	6.6
Trapezoid	6.5	7.0
Girls		
Distal ulna	6.4	7.5

nual interval varied from 10 to 27 of each sex. The modal ages for onset of ossification were markedly earlier in the California children than in the Hong Kong children. These differences probably reflect disparities between the populations in illness and nutrition; however, any interpretations should be cautious because of the small sample size. The retardation in the Hong Kong children is almost certainly environmentally determined because at younger ages they were ahead of southwestern Ohio white children in the mean ages at onset of ossification.[89]

Table S contains data relating to the age at onset of ossification of selected hand-wrist centers in California children of Japanese ancestry who were above average in socioeconomic status.[34] The sample size was small, varying from 10 to 14 for both sexes combined at each annual interval from 6 to 8 years; and 8 children aged 9 years or over. Sutow[43] reported data from a representative sample of normal Japanese children in Hiroshima. The sample size for each sex varied from 56 to 107 for each year of age. The ages at onset of ossification tended to be earlier for the children in California than for those in Japan.

Geographic Region

As expected, the ages at onset of ossification differed only slightly and nonsignificantly between the large regions into which the United States was divided for the purpose of this survey (table 15).

Socioeconomic Factors

When children were grouped according to family income, the median ages of onset of ossification showed no relationship to this socioeconomic factor. The expected delay in onset for those in lower income families was not found among these United States children. The lack of such an effect in the present national survey may be partly due to the confounding influence of racial differences. As noted earlier, onset for the trapezium tended to be earlier in Negro children, and these children were concentrated in the lower income groups.

Other studies.—The data included in table O are from United States white children who were middle class or above in socioeconomic status. The present national study data are in agreement with the previous findings from these smaller samples with the exception of the age for the trapezium in boys, which was slightly later in the present white children and considerably earlier in the Negro children.

Michelson[90] reported a mean age of onset of ossification of the pisiform in girls of 8.5 years after studying 180 underprivileged white girls in New York City for whom annual radiographs were available. The age of onset for each girl was interpolated between the age of the last radiograph in which it was not ossified and the first radiograph in which it was ossified. Consequently, 0.5 year should be added to Michelson's reported mean before comparing it with those listed in table O. After this adjustment, the reported age is similar to those reported from the studies listed, suggesting that socioeconomic status is not a major determinant of age at onset of ossification.

DISCUSSION

Throughout this discussion, comparisons will be made between the national survey findings and those from earlier studies. In interpreting these comparisons, it is important to recall that the present report describes the first national survey of skeletal maturity levels for this or any other country. While the methodology used in the national survey was heavily dependent on the work of previous investigators, differences between the present and earlier findings should be judged in relation to the accuracy of assessment and, most importantly, the representative nature of the samples. In the national survey, assessments were made of 94 percent of those subjects initially identified by the National Center for Health Statistics in collaboration with the U.S. Bureau of the Census as constituting a national probability sample.

Race

It is difficult to interpret "racial" comparisons because groups almost always differ in climate, nutrition, the prevalence of disease, and frequently in socioeconomic status, to mention some obvious factors. However, there is substantial evidence that genes influence the rate of skeletal maturation. This evidence has come from studies of pairs or triads of individuals sharing similar environments but different proportions of genes. The reported genetic influences concern the order of onset of ossification,[91-99] its rate,[92-94,96,100-106] the occurrence of skeletal variants, for example, pseudoepiphyses,[92,94,101,102] levels of hand-wrist skeletal maturity[107] and the changes in skeletal maturity with age.[107-111]

The mean skeletal ages for the white children included in the present national survey were about 0.5 year below their corresponding chronological ages. This difference tended to increase with age, which would indicate that the Greulich-Pyle Atlas standards,[6] based on a specially selected subgroup of the population, are higher than the mean values for U.S. children. The corresponding differences between chronological ages and Greulich-Pyle skeletal ages are somewhat larger for Scotch, British, and Danish children, but the reports on Polish children are conflicting; some indicate similar delays and others that mean skeletal ages are approximately equal to mean chronological ages.[25,26,31,32]

The rates of skeletal maturation are more rapid for Negro children in the United States than for those in Jamaica.[35-39] Similarly, the onset of ossification is delayed in African children[86-88] in comparison with Negro children in the United States. Data for the latter are available from the present national survey and the sample of Sproul and Peritz.[34]

The national survey data show that Negro children tend to mature skeletally somewhat more rapidly than white children in the United States. These small racial differences are statistically significant at only two ages in boys and not at any ages in the girls. These findings are in general agreement with those of earlier workers.[24,34-39,112] When the data for all ages were combined, the differences between white and Negro children were significant at the 5-percent level in boys but not in girls. Although the present survey has demonstrated a tendency for Negro children to mature skeletally more rapidly than white children, these differences are small and most of them are not statistically significant for single-year age groupings. These findings, although real, are not of sufficient magnitude to justify the creation of separate skeletal maturity scales for these two racial groups.

Among both white and Negro children, there was a tendency for skeletal age to be more advanced in the girls (female equivalent values) than in the boys; these differences were statistically significant at some ages. Earlier studies of smaller, less representative groups of children[16-19,22-24] have provided similar findings, except that of Johnston,[20] in which boys were slightly more advanced than the girls on sex-specific scales of skeletal maturity.

The national survey sample contained too few children of Chinese or Japanese ancestry for their data to be analyzed separately. Findings from generally small and unrepresentative groups have suggested that such children living in the United States mature more rapidly than children of similar ancestry living in their country of origin.[34,40,41,43-46,51,52]

About 60 percent of the mean bone-specific skeletal ages were more advanced in Negro children than white children. Many of these differences were statistically significant and consistent across age, indicating that different modal patterns of hand-wrist maturation occur between races. These differences were generally marked for the radius, ulna, capitate, hamate, triquetral, lunate, scaphoid, trapezium, and metacarpals I-V, when considered within annual intervals. Each of these bones was considerably more advanced in Negro children. The pattern of bone-specific skeletal ages (expressed as skeletal age less chronological age) for all ages combined was similar for each sex within each group. While the means (SA-CA) for white children were close to zero, the skeletal ages of the radius, ulna, carpals and metacarpals were advanced about 3 months in Negro children. The proximal phalanges II-V tended to be somewhat more advanced in white than in Negro boys and girls. In an earlier study, the radius was more advanced in Negro boys than in white boys living in Philadelphia.[36,76] In the Negro girls, the radius, ulna, metacarpal III, proximal phalanges I, III, and V, and distal phalanx I were more advanced than in white girls. The magnitude of the bone-specific skeletal age differences between white and Negro children found in this survey and the earlier study[36,76] are probably insufficient to justify separate standards for Negro children. These differences are small but real, however, and they are contrary to the assertion of Greulich and Pyle[6] that the pattern of maturation is the same in all racial groups. There are few previous relevant findings, but tendencies to variations among bones in the extents to which they differ from Greulich-Pyle skeletal maturity levels have been reported for children in Hong Kong, Dakar, and Melbourne.[4,86,89]

The assessments on which the present analysis was based were made without knowledge of the sex or race of any child, as previously mentioned. The small racial differences found among boys and girls for each of the bone-specific skeletal ages provide convincing evidence that the assessments were highly reliable. Hence, the remarkable similarity of race-specific patterns in each sex, illustrated in figure 15, strongly suggests that the differences between the racial patterns are, indeed, real.

Geographic Region

Analyses of the national survey data by geographic region were somewhat unrewarding, largely because the four major geographic regions of the United States were too diverse to demonstrate possible real differences, as discussed in an earlier report.[113] After the effects of differences in the age and racial distributions were removed, children in the Northeastern and Midwestern Regions tended to be advanced in comparison with the others. This tendency occurred for both white and Negro children. However, most of the differences in skeletal maturity (age at onset of ossification, means and ranges of bone-specific skeletal ages and area skeletal ages) could have been due to chance. The mean skeletal ages tended to be more advanced in girls (female equivalent values) than boys in each region, but these differences were statistically significant for few annual intervals. In each region there was a decrease in the coefficients of variability with age from 6 through 10 years.

Real differences were not present between urban and rural children in levels of skeletal maturity. Presumably this reflects a corresponding lack of major differences between these areas in factors that can influence the rate of skeletal maturation. A similar lack of urban-rural differences in growth (body size) has been reported for the United States and the factors responsible have been reviewed fully.[114]

Socioeconomic Factors

These factors can influence skeletal maturation because they are related to child care, particularly the quality of the diet and the frequency of disease. Direct dietary measures were not made in the national survey. Consequently, family income, which is highly correlated with the educational level of the father, is used here as a measure of socioeconomic status and an indirect measure of child care.

As expected, there was slight association between socioeconomic status (income level) and skeletal maturity in U.S. children from the HES data. There was a consistent tendency among white children for skeletal maturation to be more rapid in the higher income groups. Among Negro children, the pattern of association between family income and the rate of skeletal maturation was less consistent, because the sample size was not large enough to provide consistently reliable estimates for that small group. Previous studies in countries with much more pronounced socioeconomic differences between segments of the population have demonstrated higher skeletal maturity levels in upper socioeconomic groups but the differences between the means for high and low socioeconomic groups did not exceed one year and were considerably smaller in most studies.[26,27,31,70-75]

Comparisons between large samples from extreme groups are needed to determine whether such effects are really present; the sample used for the Health Examination Survey was not large enough for this. When the HES bone-specific skeletal ages for all races combined were considered within only three income groups, an association was not apparent. When the skeletal ages for six representative bones were considered within six income groups, there was a definite pattern of more advanced maturity with increasing income. This is in general agreement with a recent report from a 1968-70 Ten-State Nutrition Survey, contrasting ages at onset of ossification in high and low socioeconomic groups separated on an income-needs ratio.[115] In data from the present national survey this effect was most marked in the third and fourth proximal phalanges and the fifth middle phalanx, indicating that these bones might be more sensitive than other hand-wrist bones to environmental effects.

Lower socioeconomic status is associated with a higher frequency of illness during childhood.[49,116] Consequently, it is appropriate to consider whether illness affects the rate of skeletal maturation. Pryor[117,118] may have been the first to suggest that illness could retard skeletal maturation. This occurs with severe illnesses, but there may be an acceleration in skeletal maturation during catch-up growth after the illness.[119,120]

It has been claimed that even apparently minor illnesses retard skeletal maturation in preschool boys but not girls,[121,122] but other investigators have reported either no effects on both sexes[123-125] or effects on both sexes.[126]

There is a general tendency for retarded onset of ossification in the hand-wrist to be associated with more childhood illness as reported on health histories, but occasionally early onset of ossification has been reported in association with severe illness.[127,128] Other investigators, after excluding children with chronic diseases, have found no association between illness and the age of onset of ossification.[128] Some observers have reported that all centers are retarded equally by childhood illness;[129] others that illnesses retard carpal centers more than epiphyseal ones.[119,130-132] Without reported evidence, it has been claimed that illness, about the time a center would have ossified, retards its ossification but this has been denied.[6,95,119,128,133-136] Such an effect would, of course, give rise to unusual orders of ossification.

It is difficult to summarize the findings of studies concerning the effects of illness on the rate of skeletal maturation, since these studies differ in the methodology by which illness histories were obtained and the influences of possible confounding variables have been ignored. There seems to be little doubt that severe illness can retard all phases of skeletal maturation, but no such conclusion would be justified for minor illnesses.

Marked undernutrition retards skeletal maturation and dietary supplementation accelerates it, both in experimental animals and children.[18,70,137-139,140-147] Despite one contrary report,[148] it is generally agreed that malnutrition also retards the onset of ossification.[60,149] In preschool Negro children this delay is greater in boys than girls and is more marked in the metacarpals than other hand-wrist bones.[150] Others have stated that in older Negro children the most sensitive hand-wrist bones are the carpals and the distal end of the ulna,[63,141] but some have claimed almost the reverse in African and Japanese children.[41,143,151] These contradictions between reported findings presumably result from differences in subject selection and methodology among the studies cited, of which the most obvious are the racial ones.

Reported findings that malnutrition has differential effects on maturation across bones must be considered in relation to Todd's[18] attitude that the principle of assessment is the utilization of the most advanced centers as a guide to actual bodily maturity. This principle would lead to use of the centers least sensitive to environmental influences and thereby reduce the sensitivity of assessments. The report[152] that the least retarded centers tend to respond most when undernourished children are given dietary supplements is analogous to the general growth response to improvements in the environment.[153] When adverse environmental factors, such as famine, are operating, girls are less affected than boys but they respond more quickly than boys to a subsequent improvement in the environment.[154] Skeletal maturation is slow also in children with ulcerative colitis, regional enteritis or celiac disease, but "explosive" increases in the number of ossified centers occur with treatment.[155,156]

In general, skeletal maturation is accelerated in overfed experimental animals[157] and obese children.[158-163] This acceleration is marked in long term obesity[164] and especially when lean body mass is increased also;[165] it is greater in the late than the early ossifying carpals.[163]

Few have studied the effects of specific nutrients. Skeletal maturation is retarded in gross malnutrition whether the main lack is in calories or protein[48,142,143,149] but protein intake may be the more important factor.[166] A lack of association between the level of calcium intake, within the range studied, and the level of skeletal maturity either at the same age or later has been reported,[123] but others have reported a tendency to skeletal retardation with very low calcium intakes.[167] Relationships between the age at onset of epiphyseal ossification and the intakes of calcium and vitamin D have been reported.[120,132]

SUMMARY

The skeletal maturity levels in the hand-wrist of noninstitutionalized children 6-11 years of age in the United States as estimated from the Health Examination Survey of 1963-65 have been described and analyzed by race, area of residence, and socioeconomic background in this report. A probability sample of 7,417 children representative of the nearly 24 million noninstitutionalized children in the United States was selected; of these, 7,119 (96 percent of the sample) were examined. Radiographs of the right hand-wrist suitable for assessment were obtained from 6,962 (98 percent of the examined group or 94 percent of the total sample).

These radiographs were assessed by specially trained medical students who knew neither the age nor the sex of any child whose radiograph was assessed, thus eliminating several possible sources of bias in these ratings. All assessments were made against male standards; later the skeletal ages for girls were adjusted by computer to female equivalent values, bone by bone, using the sex-associated differences in maturity reported by Pyle et al.[9]

The skeletal maturity levels of white boys and girls 6-11 years of chronological age generally tend to be somewhat less advanced than those of Negro boys and girls in the United States. The rates of skeletal maturation for Negro children in the United States are more rapid than for those Negro groups in Jamaica or in Africa reported previously by others. Among United States white and Negro children there is a tendency for skeletal age to be more advanced in girls than boys by approximately the same magnitude in each race.

For 19 of the 31 individual hand-wrist bones the mean skeletal age of United States white children lags consistently behind that for Negro children of corresponding chronological age, with minor exceptions. In particular, mean skeletal ages for the radius, ulna, all carpals, and all metacarpals are advanced about 3 months in Negro boys and girls compared with white children, but the proximal phalanges are slightly retarded. These racial differences are consistent in both sexes; the differences between the two groups of boys are similar to those between the two groups of girls. These small but consistent race-specific differences within each sex provide strong evidence that the racial differences are indeed real.

No statistically significant differences among geographic regions of the United States were found in the levels of skeletal maturity, although children in the Northeast and Midwest tended to

be more advanced in this respect than those in the West and South.

No urban-rural difference was found in the skeletal maturity levels of United States children.

Socioeconomic status as measured by family income levels shows a slight but generally consistent relationship to the level of skeletal maturity of United States children 6-11 years of chronological age, with a pattern of increasing skeletal maturity with increasing income.

These national estimates of skeletal maturity levels for children 6-11 years of chronological age delineate for the first time the approximate magnitudes of the differences in these levels between races, broad geographic regions of the United States, and socioeconomic groups. Although real, these racial, socioeconomic, and geographic differences in skeletal maturity among United States children are not considered large enough to justify the creation of separate standards.

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LIST OF DETAILED TABLES

Table 1. Mean, standard deviation, and standard error of the mean skeletal age (hand-wrist) of boys and girls, by race and chronological age at last birthday: United States, 1963-65

Standard of reference, sex, and chronological age at last birthday	White			Negro			Other	
	$\bar{x}$	s_x	$s_{\bar{x}}$	$\bar{x}$	s_x	$s_{\bar{x}}$	$\bar{x}$	$s_{\bar{x}}$
Male standard								
Boys	Skeletal age in months							
6 years	74.9	11.49	0.64	79.0	10.78	1.29	91.2	46.68
7 years	86.7	11.57	0.60	88.1	12.94	1.41	85.7	43.70
8 years	96.3	11.94	0.55	100.8	10.11	1.35	95.1	48.65
9 years	105.6	11.39	0.47	106.3	10.58	0.67	111.6	4.73
10 years	113.6	10.23	0.52	112.2	10.27	1.04	109.9	55.17
11 years	123.8	13.06	0.59	125.8	13.66	0.76	133.0	67.08
Girls								
6 years	89.7	12.50	0.65	91.9	13.44	1.54	89.3	37.66
7 years	100.9	12.12	0.53	102.9	11.85	0.95	99.2	31.59
8 years	111.3	12.06	0.59	111.3	14.27	1.14	112.6	57.63
9 years	122.1	14.33	0.85	125.2	18.33	1.63	144.9	50.19
10 years	137.0	17.28	0.77	141.5	17.65	2.02	149.9	76.30
11 years	156.2	14.68	0.60	157.6	17.28	1.29	162.1	62.79
Female equivalent								
Girls								
6 years	76.7	10.69	0.56	78.9	11.54	1.32	76.3	32.18
7 years	87.9	10.56	0.46	88.9	10.24	0.82	86.2	27.45
8 years	96.3	10.43	0.51	96.3	12.35	0.99	97.6	49.95
9 years	107.1	12.57	0.75	109.2	15.99	1.42	120.9	41.88
10 years	116.5	14.69	0.65	119.2	14.87	1.70	123.9	63.07
11 years	128.1	12.04	0.49	128.8	14.12	1.05	131.1	50.78
Male standard								
Actual values								
Boys: 6-11 years	99.9	20.08	0.28	101.6	19.11	0.57	105.9	5.51
Girls: 6-11 years	119.1	26.17	0.25	120.9	27.28	0.70	126.4	10.34
Expected values								
Boys: 6-11 years	100.2	20.14	0.28	100.0	18.81	0.56	101.9	5.30
Girls: 6-11 years	119.4	26.24	0.25	119.0	26.85	0.69	118.5	9.69

NOTE: $\bar{x}$ = mean skeletal age; s_x = standard deviation of skeletal age; and $s_{\bar{x}}$ = standard error of mean. Expected values remove the effect of differences in the chronological age distribution with respect to skeletal age over the age (chronological) span 6-11 years by indirect adjustment.

Table 2. Mean, standard deviation, and standard error of the mean skeletal age (hand-wrist) of boys and girls, by geographic region and chronological age at last birthday: United States, 1963-65

Standard of reference, sex, and chronological age at last birthday	Northeast			Midwest			South			West		
	$\bar{x}$	s_x	$s_{\bar{x}}$	$\bar{x}$	s_x	$s_{\bar{x}}$	$\bar{x}$	s_x	$s_{\bar{x}}$	$\bar{x}$	s_x	$s_{\bar{x}}$
Male standard												
Boys	Skeletal age in months											
6 years	76.7	11.09	0.75	75.3	12.23	1.17	74.8	10.97	0.64	75.4	11.65	1.18
7 years	88.1	12.05	0.60	88.9	12.57	1.58	85.1	10.81	1.08	85.5	11.14	1.40
8 years	98.2	12.42	1.35	96.9	10.87	0.75	97.5	11.77	0.51	95.4	12.12	1.15
9 years	106.4	12.45	0.72	107.0	11.27	0.69	105.7	10.38	0.83	103.7	10.72	1.30
10 years	114.3	10.74	0.56	113.9	10.26	0.53	113.7	11.06	0.70	111.8	8.75	1.36
11 years	127.2	13.24	0.83	123.2	12.59	0.79	123.0	12.72	0.68	123.7	13.80	1.99
Girls												
6 years	91.5	12.77	0.64	93.3	12.96	0.71	88.3	12.02	0.99	87.4	12.35	0.85
7 years	103.2	12.25	0.56	101.7	11.25	0.93	99.6	12.47	1.60	100.0	12.24	1.01
8 years	112.0	13.05	0.50	112.7	11.90	1.17	110.4	12.92	1.37	110.0	11.59	1.40
9 years	127.9	16.60	1.22	122.4	12.83	0.67	121.8	15.61	1.19	118.8	15.15	2.14
10 years	136.7	18.66	1.58	139.0	17.28	1.86	137.5	16.85	1.65	137.1	17.22	1.41
11 years	157.5	15.04	1.78	155.1	14.17	1.07	156.0	16.46	0.67	158.0	14.07	2.24
Female equivalent												
Girls												
6 years	78.5	10.96	0.55	80.3	11.15	0.61	75.3	10.25	0.84	74.4	10.51	0.72
7 years	89.2	10.59	0.48	88.4	9.78	0.80	86.6	10.84	1.39	87.0	10.65	0.88
8 years	97.0	11.30	0.43	97.7	10.32	1.01	95.7	11.20	1.19	95.5	10.06	1.22
9 years	110.9	14.39	1.06	107.4	11.26	0.59	106.8	13.69	1.04	103.8	13.24	1.87
10 years	116.4	15.89	1.35	118.0	14.67	1.58	116.8	14.31	1.40	116.5	14.64	1.20
11 years	128.8	12.30	1.46	127.1	11.61	0.88	128.0	13.51	0.55	129.0	11.49	1.83
Male standard												
Actual values												
Boys: 6-11 years	101.4	20.47	0.69	101.3	19.53	0.36	98.8	20.05	0.56	99.0	19.77	1.29
Girls: 6-11 years	119.2	26.05	0.82	120.9	25.06	0.92	119.7	27.34	0.90	117.3	27.12	1.06
Expected values												
Boys: 6-11 years	100.1	20.21	0.68	100.9	19.45	0.36	99.3	20.15	0.56	100.2	20.01	1.31
Girls: 6-11 years	117.6	25.70	0.81	120.2	24.91	0.91	120.7	27.57	0.91	118.8	27.47	1.07

NOTE: $\bar{x}$ = mean skeletal age; s_x = standard deviation of skeletal age; and $s_{\bar{x}}$ = standard error of mean. Expected values remove the effect of differences in the chronological age distribution with respect to skeletal age over the age (chronological) span 6-11 years by indirect adjustment.

Table 3. Mean, standard deviation, and standard error of the mean skeletal age (hand-wrist) of boys and girls, by annual family income and chronological age at last birthday: United States, 1963-65

Standard of reference, sex, and chronological age at last birthday	Less than $5,000			$5,000-$9,999			$10,000 or more			Less than $3,000		$15,000 or more	
	$\bar{x}$	s_x	$s_{\bar{x}}$	$\bar{x}$	s_x	$s_{\bar{x}}$	$\bar{x}$	s_x	$s_{\bar{x}}$	x	$s_{\bar{x}}$	$\bar{x}$	$s_{\bar{x}}$
Male standard													
Boys	Skeletal age in months												
6 years	75.1	11.50	0.77	76.6	11.15	0.76	73.6	12.00	1.58	73.4	1.21	74.3	1.46
7 years	85.9	12.14	1.21	87.6	11.82	0.66	87.9	10.58	1.14	85.1	2.42	87.2	1.99
8 years	96.7	12.06	0.62	96.9	11.25	0.59	96.9	12.60	1.43	96.5	0.92	97.6	4.72
9 years	104.3	11.04	1.18	106.2	10.85	0.60	107.9	12.00	1.11	102.5	1.41	107.8	3.54
10 years	112.9	10.52	0.80	114.4	10.25	0.55	112.2	9.50	0.77	112.5	1.14	113.9	1.93
11 years	124.9	14.00	0.85	123.6	13.20	0.95	124.8	12.04	1.05	124.5	1.49	125.8	2.54
Girls													
6 years	90.0	13.26	0.81	90.4	12.23	0.84	89.7	12.08	1.34	90.4	0.93	91.6	3.77
7 years	100.9	12.74	1.22	101.2	11.76	0.52	101.6	12.00	1.68	101.5	1.30	107.2	2.92
8 years	110.3	11.30	0.69	112.5	12.95	0.99	110.3	11.14	1.51	107.9	1.07	110.7	2.28
9 years	120.4	15.19	0.63	124.1	15.60	1.46	125.4	14.12	2.17	120.4	1.10	124.8	1.86
10 years	137.7	17.95	1.63	137.2	16.95	0.88	138.2	18.44	1.82	138.5	1.89	141.5	3.83
11 years	156.3	15.43	1.19	156.9	15.07	0.85	156.0	14.52	1.63	156.2	1.50	158.8	3.48
Female equivalent													
Girls													
6 years	77.0	11.34	0.69	77.4	10.47	0.72	76.7	10.33	1.15	77.4	0.80	78.6	3.24
7 years	87.9	11.10	1.06	88.1	10.24	0.45	88.3	10.43	1.46	88.2	1.13	93.2	2.54
8 years	95.6	9.79	0.60	97.5	11.22	0.86	95.6	9.66	1.31	93.9	0.93	95.8	1.97
9 years	105.4	13.30	0.55	108.6	13.65	1.28	109.4	12.32	1.89	105.4	0.96	108.9	1.62
10 years	116.8	15.23	1.38	116.6	14.40	0.75	117.2	15.64	1.54	117.5	1.60	119.2	3.23
11 years	128.2	12.66	0.98	128.4	12.33	0.70	128.0	11.91	1.34	128.1	1.23	129.4	2.84
Male standard													
Actual values													
Boys: 6-11 years	99.1	20.42	0.66	100.8	19.37	0.46	100.9	20.68	0.97	98.3	1.08	100.1	2.17
Girls: 6-11 years	118.4	26.41	0.79	119.6	26.36	0.62	121.6	26.21	0.99	118.5	1.09	123.8	2.02
Expected values													
Boys: 6-11 years	99.6	20.52	0.66	100.4	19.29	0.46	100.7	20.66	0.97	99.6	1.09	100.5	2.18
Girls: 6-11 years	119.0	26.54	0.79	119.1	26.25	0.62	120.7	26.23	0.99	119.1	1.10	121.4	1.98

NOTE: $\bar{x}$ = mean skeletal age; s_x = standard deviation of skeletal age; and $s_{\bar{x}}$ = standard error of mean. Expected values remove the effect of differences in the chronological age distribution with respect to skeletal age over the age (chronological) span 6-11 years by indirect adjustment.

Table 4. Mean and standard error of the mean skeletal age (hand-wrist) of white and Negro boys and girls, by geographic region and chronological age at last birthday: United States, 1963-65

Standard of reference, sex, and chronological age at last birthday	Northeast				Midwest			
	White		Negro		White		Negro	
	$\bar{X}$	$s_{\bar{X}}$	$\bar{X}$	$s_{\bar{X}}$	$\bar{X}$	$s_{\bar{X}}$	$\bar{X}$	$s_{\bar{X}}$
Male standard								
Boys	Skeletal age in months							
6 years	76.4	1.03	79.0	3.19	74.8	1.31	80.3	3.12
7 years	88.2	0.69	87.4	2.66	88.9	1.54	88.9	4.12
8 years	98.0	1.37	99.7	3.06	96.5	1.19	100.6	6.73
9 years	106.3	0.72	107.6	3.30	106.9	0.62	108.3	2.57
10 years	114.2	0.79	114.7	2.21	114.2	0.58	111.3	2.12
11 years	127.3	0.91	126.4	2.70	122.9	0.91	127.2	6.38
Girls								
6 years	91.3	0.96	92.9	5.02	93.2	0.84	98.0	31.81
7 years	103.0	0.71	104.8	1.61	101.6	1.04	102.4	1.72
8 years	111.6	0.55	115.0	1.02	112.1	1.44	120.0	7.44
9 years	126.8	1.54	128.8	4.55	122.4	0.91	122.5	3.14
10 years	135.5	1.88	144.4	2.38	138.5	1.83	146.2	15.45
11 years	157.6	1.65	156.5	5.54	154.8	0.92	157.6	3.16
Female equivalent								
Girls								
6 years	78.3	0.82	79.9	4.32	80.2	0.72	85.0	27.59
7 years	89.0	0.61	90.8	1.39	88.3	0.90	88.7	1.49
8 years	96.6	0.48	100.0	0.89	97.1	1.25	105.0	6.51
9 years	110.4	1.34	111.8	3.95	107.4	0.80	107.5	2.76
10 years	115.8	1.61	120.7	1.99	117.5	1.55	122.1	12.90
11 years	128.8	1.35	128.2	4.54	126.9	0.75	128.8	2.58
Male standard								
Actual values								
Boys: 6-11 years	101.2	0.72	103.3	2.23	101.2	0.41	102.9	1.50
Girls: 6-11 years	118.5	0.87	123.2	3.00	120.8	0.92	123.1	2.04
Expected values								
Boys: 6-11 years	99.6	0.71	102.8	2.22	100.6	0.41	102.4	1.49
Girls: 6-11 years	117.0	0.86	121.1	2.95	120.0	0.91	121.0	2.01

NOTE: $\bar{X}$ = mean skeletal age; $s_{\bar{X}}$ = standard error of mean. Expected values remove the effect of differences in the chronological age distribution with respect to skeletal age over the age (chronological) span 6-11 years by indirect adjustment.

Table 4. Mean and standard error of the mean skeletal age (hand-wrist) of white and Negro boys and girls, by geographic region and chronological age at last birthday: United States, 1963-65—Con.

Standard of reference, sex, and chronological age at last birthday	South				West			
	White		Negro		White		Negro	
	$\bar{x}$	$s_{\bar{x}}$	$\bar{x}$	$s_{\bar{x}}$	$\bar{x}$	$s_{\bar{x}}$	$\bar{x}$	$s_{\bar{x}}$
Male standard								
Boys	Skeletal age in months							
6 years	73.4	1.41	79.2	1.96	75.0	1.12	77.4	24.70
7 years	83.5	1.30	89.0	2.33	85.7	1.54	83.8	26.63
8 years	95.8	0.62	101.0	0.59	95.0	1.27	101.5	5.34
9 years	105.9	1.23	105.2	0.45	103.3	1.31	110.3	42.79
10 years	114.5	0.93	110.8	2.26	111.7	1.46	113.9	5.79
11 years	122.3	0.62	124.9	1.97	123.3	1.96	126.1	40.23
Girls								
6 years	87.3	1.30	90.6	1.78	87.0	0.76	89.1	28.82
7 years	98.4	1.67	103.0	2.07	100.0	0.84	100.1	9.24
8 years	111.1	1.68	108.4	1.95	110.4	1.31	105.4	2.55
9 years	120.4	1.87	125.6	2.62	118.6	2.11	122.2	1.09
10 years	136.6	2.14	139.9	3.15	136.7	1.20	139.4	44.27
11 years	155.4	0.85	157.6	0.92	157.8	2.08	160.5	5.29
Female equivalent								
Girls								
6 years	74.3	1.11	77.6	1.52	74.0	0.65	76.1	24.62
7 years	85.4	1.45	89.0	1.79	87.0	0.73	87.1	8.04
8 years	96.1	1.45	94.4	1.70	95.7	1.14	91.4	2.21
9 years	105.4	1.64	109.6	2.29	103.6	1.84	107.2	0.96
10 years	116.3	1.82	118.4	2.67	116.4	1.02	118.2	37.54
11 years	127.4	0.70	128.8	0.75	128.9	1.70	130.2	4.29
Male standard								
Actual values								
Boys: 6-11 years	98.1	0.96	100.6	1.11	98.7	1.16	101.2	3.56
Girls: 6-11 years	119.5	1.15	120.5	1.84	117.3	1.11	115.8	4.66
Expected values								
Boys: 6-11 years	99.1	0.97	100.9	1.11	99.9	1.17	101.4	3.57
Girls: 6-11 years	120.8	1.16	121.4	1.85	118.6	1.12	118.5	4.77

NOTE: $\bar{x}$ = mean skeletal age; s_x = standard deviation of skeletal age; and $s_{\bar{x}}$ = standard error of mean. Expected values remove the effect of differences in the chronological age distribution with respect to skeletal age over the age (chronological) span 6-11 years by indirect adjustment.

Table 5. Mean and standard error of the mean skeletal age (hand-wrist) of white and Negro boys and girls, by annual family income and chronological age at last birthday: United States, 1963-65

Standard of reference, sex, and chronological age at last birthday	Less than $5,000				$5,000-$9,999				$10,000 or more				Under $3,000				$15,000 or more			
	White		Negro		White		Negro		White		Negro		White		Negro		White		Negro	
	$\bar{x}$	$s_{\bar{x}}$	$\bar{x}$	$s_{\bar{x}}$	$\bar{x}$	$s_{\bar{x}}$	$\bar{x}$	$s_{\bar{x}}$	$\bar{x}$	$s_{\bar{x}}$	$\bar{x}$	$s_{\bar{x}}$	$\bar{x}$	$s_{\bar{x}}$	$\bar{x}$	$s_{\bar{x}}$	$\bar{x}$	$s_{\bar{x}}$	$\bar{x}$	$s_{\bar{x}}$
Male standard																				
Boys	Skeletal age in months																			
6 years	73.5	1.08	79.8	1.59	76.4	0.83	77.6	1.68	73.3	1.58	87.6	43.87	74.9	0.64	79.0	1.29	74.3	1.46	—	—
7 years	85.4	1.62	87.4	1.82	87.3	0.74	92.0	3.81	87.9	1.14	—	—	86.7	0.60	88.1	1.41	87.2	1.99	—	—
8 years	94.4	0.85	102.1	0.89	96.9	0.69	95.7	4.37	97.0	1.35	105.0	74.24	96.3	0.55	100.8	1.35	98.2	4.43		
9 years	103.5	1.57	106.5	1.33	106.2	0.62	105.7	1.81	107.9	1.11	—	—	105.6	0.47	106.3	0.67	107.8	3.54	—	—
10 years	113.0	1.08	112.7	1.11	114.7	0.54	110.0	1.50	112.6	0.85	101.0	50.49	113.6	0.52	112.2	1.04	114.4	2.03	—	—
11 years	124.0	0.96	127.3	1.34	123.7	0.92	122.0	2.09	124.8	1.05	—	—	123.8	0.59	125.8	0.76	125.8	2.54	—	—
Girls																				
6 years	89.3	1.09	91.6	1.63	90.2	0.85	96.0	2.33	89.7	1.34	—	—	89.7	0.65	91.9	1.54	91.6	3.77	—	—
7 years	100.1	1.45	102.9	1.69	101.3	0.62	101.4	1.94	101.4	1.70	106.3	53.29	100.9	0.53	102.9	0.95	107.2	2.92	—	—
8 years	110.5	0.82	109.7	1.60	112.1	0.97	115.9	3.67	110.2	1.51	118.7	59.57	111.3	0.59	111.3	1.14	110.7	2.28	—	—
9 years	118.8	0.98	124.8	2.36	124.0	1.54	127.0	3.34	124.0	1.26	—	—	122.1	0.85	125.2	1.63	124.8	1.86	—	—
10 years	136.6	2.07	140.9	2.91	136.8	0.93	141.6	3.78	138.2	1.82	—	—	137.0	0.77	141.5	2.02	141.5	3.83	—	—
11 years	155.0	1.47	160.0	1.81	157.0	0.86	155.1	2.79	155.9	1.65	—	—	156.2	0.60	157.6	1.29	158.5	3.70	—	—
Female equivalent																				
Girls																				
6 years	76.3	0.93	78.6	1.40	77.2	0.73	83.0	2.01	76.7	1.15	—	—	76.7	0.56	78.9	1.32	78.6	3.23	—	—
7 years	87.1	1.26	88.9	1.46	88.2	0.54	88.2	1.69	88.2	1.48	92.3	46.27	87.9	0.46	88.9	0.82	93.2	2.54	—	—
8 years	95.8	0.71	95.4	1.39	97.1	0.84	100.9	3.20	95.6	1.31	103.7	52.04	96.3	0.51	96.3	0.99	95.8	1.97	—	—
9 years	103.8	0.86	108.4	2.05	108.5	1.35	110.5	2.91	108.5	1.10	—	—	107.1	0.75	109.2	1.42	108.9	1.62	—	—
10 years	116.3	1.76	118.9	2.46	116.4	0.79	119.3	3.18	117.2	1.54	—	—	116.5	0.65	119.2	1.70	119.2	3.23		
11 years	127.0	1.20	130.0	1.47	128.5	0.70	127.1	2.29	127.9	1.35	—	—	128.1	0.49	128.8	1.05	129.2	3.02	—	—
Male standard																				
Actual values																				
Boys: 6-11 years	97.9	0.90	102.2	0.85	100.8	0.54	100.2	1.74	100.9	0.97	97.4	7.32	99.9	0.28	101.6	0.57	101.3	2.12	—	—
Girls: 6-11 years	117.9	0.91	119.6	1.22	119.3	0.63	123.9	2.04	120.4	0.93	110.2	34.87	119.1	0.25	120.9	0.70	123.4	1.99	—	—
Expected values																				
Boys: 6-11 years	98.9	0.91	99.5	0.83	100.8	0.54	100.5	1.75	100.9	0.97	96.3	7.24	100.2	0.28	100.0	0.57	101.1	2.12	—	—
Girls: 6-11 years	118.8	0.92	117.3	1.20	119.4	0.63	121.9	2.01	120.6	0.93	104.4	33.03	119.4	0.25	119.0	0.70	123.5	1.99	—	—

NOTE: $\bar{x}$ = mean skeletal age; $s_{\bar{x}}$ = standard error of mean. Expected values remove the effect of differences in the chronological age distribution with respect to skeletal age over the age (chronological) span 6-11 years by indirect adjustment.

Table 6. Mean skeletal age (hand-wrist) of boys and girls, by population size in urban areas and land use in rural areas of residence and chronological age at last birthday, with selected standard errors: United States, 1963-65

Standard of reference, sex, and chronological age at last birthday	Urban total	Urbanized areas				Urban outside urbanized areas			Rural total	Rural-farm		Rural-nonfarm	
		3 million or more	1.0-2.9 million	250,000-999,999	Less than 250,000	25,000 or more	10,000-24,999	2,500-9,999		10 acres or more	Less than 10 acres	10 acres or more	Less than 10 acres
Male standard	Mean skeletal age in months												
6 years	75.6	77.3	77.1	74.3	73.8	74.2	76.6	74.4	75.1	76.2	69.4	78.1	75.0
7 years	86.7	87.5	86.3	86.5	88.8	85.6	84.0	85.7	87.4	89.3	---	85.0	86.9
8 years	97.4	98.6	97.6	93.9	97.7	98.4	99.3	97.0	95.9	95.6	---	93.5	96.4
9 years	106.1	106.6	105.6	106.8	106.6	104.1	104.2	105.8	105.2	104.8	103.0	104.9	105.3
10 years	113.1	113.4	113.6	111.0	111.6	113.8	116.7	114.1	114.0	116.0	118.0	111.1	114.0
11 years	124.2	126.8	125.4	124.0	123.1	122.5	120.6	120.1	124.1	122.4	153.0	122.1	124.4
Girls													
6 years	89.6	89.9	91.8	87.7	89.9	90.8	86.0	86.7	91.0	92.9	80.0	90.5	90.6
7 years	101.6	103.5	101.0	102.1	99.7	98.2	100.9	100.8	100.5	100.2	84.0	95.2	101.2
8 years	111.4	113.8	111.6	109.2	109.4	107.6	117.8	109.4	111.3	112.4	103.0	112.2	110.9
9 years	122.9	126.8	120.4	120.4	121.3	122.2	128.9	117.8	122.6	120.9	111.8	125.7	122.6
10 years	137.5	138.8	137.0	134.5	140.1	138.5	142.8	136.4	137.9	138.9	---	134.5	138.1
11 years	156.6	157.1	152.8	155.8	158.7	157.4	159.4	162.6	156.1	157.9	159.3	155.7	155.7
Female equivalent													
Girls													
6 years	76.6	76.9	78.8	74.7	76.9	77.8	73.0	73.7	78.0	79.9	66.0	77.5	77.6
7 years	88.3	89.5	88.0	88.6	86.7	85.2	87.9	87.8	87.5	87.2	71.0	82.2	88.1
8 years	96.4	98.8	96.6	95.1	95.2	93.6	102.8	95.2	96.3	97.4	89.0	97.2	95.9
9 years	107.9	110.4	105.4	105.4	106.3	107.2	111.9	102.8	107.6	105.9	96.8	109.7	107.6
10 years	116.8	117.8	116.5	115.2	118.6	117.5	119.9	116.2	116.9	117.9	---	115.2	117.1
11 years	128.3	128.6	125.8	127.8	129.4	128.7	129.7	131.6	128.0	128.9	129.6	127.7	127.7
Male standard													
Boys	Standard error of the mean												
6 years	0.59	0.56	2.53	1.23	2.17	5.98	4.35	1.49	0.94	3.27	35.37	2.73	1.07
11 years	0.71	0.95	1.20	1.62	1.12	3.47	2.04	4.47	0.66	1.69	108.18	2.47	0.81
Girls													
6 years	0.77	1.07	2.03	2.78	2.62	3.10	19.29	1.70	0.74	3.28	56.56	5.87	1.05
11 years	0.96	1.89	1.60	2.72	3.13	2.58	35.77	4.33	0.72	2.04	79.80	8.34	1.32
Male standard													
Actual mean	Mean skeletal age in months												
Boys: 6-11 years	100.3	101.1	101.2	99.3	100.4	100.3	100.5	98.1	99.8	100.1	90.9	101.8	99.5
Girls: 6-11 years	119.3	120.6	119.2	119.0	119.2	116.0	122.8	117.4	119.5	121.0	108.8	121.3	118.9
Expected mean													
Boys: 6-11 years	100.2	99.8	100.7	100.4	100.6	101.0	100.6	99.0	99.9	99.8	90.7	103.2	99.7
Girls: 6-11 years	119.3	118.7	119.9	120.7	119.2	117.0	120.2	118.7	119.5	120.5	117.5	121.9	118.9
	Standard error of the mean												
Boys: 6-11 years	0.34	0.49	0.86	1.16	2.58	2.31	2.50	1.91	0.59	1.28	31.00	2.60	0.89
Girls: 6-11 years	0.43	0.87	1.24	1.64	1.28	1.75	3.57	2.15	0.59	1.15	14.79	2.99	0.52

Table 7. Mean skeletal age (hand-wrist) of boys and girls, by education of first patent and chronological age at last birthday, with selected standard errors: United States, 1963-65

Standard of reference, sex, and chronological age at last birthday	Education of first parent							
	Less than 5 years	5-7 years	8 years	9-11 years	12 years	13-15 years	16 years	17 or more years
Male standard								
Boys	Mean skeletal age in months							
6 years	72.5	75.8	77.1	74.6	76.4	75.3	77.1	74.1
7 years	83.7	82.5	87.7	87.1	87.3	89.3	89.4	84.4
8 years	96.2	97.2	97.5	97.6	95.5	99.1	96.3	99.3
9 years	103.8	105.1	105.9	105.5	105.9	107.1	107.5	105.2
10 years	112.6	112.9	113.8	113.5	113.7	114.5	113.0	112.4
11 years	122.0	126.7	123.2	122.7	123.7	127.8	124.7	126.8
Girls								
6 years	88.6	87.3	91.9	89.0	90.8	90.4	92.5	86.3
7 years	98.4	101.1	101.2	100.8	101.4	104.6	98.5	103.8
8 years	107.8	110.7	109.5	112.8	111.6	113.5	112.2	109.4
9 years	120.0	120.5	122.2	123.4	122.8	124.8	124.3	126.0
10 years	139.1	136.0	135.5	137.9	138.7	133.4	143.6	137.9
11 years	154.1	156.3	155.8	157.9	155.2	158.2	158.1	159.6
Female equivalent								
Girls								
6 years	75.6	74.3	78.9	76.0	77.8	77.4	79.5	73.3
7 years	85.4	88.0	88.1	87.8	88.2	90.6	85.5	89.8
8 years	93.8	95.8	95.2	97.8	96.6	98.5	97.2	95.2
9 years	105.0	105.5	107.2	108.2	107.8	108.9	108.6	110.0
10 years	118.0	116.0	115.8	116.9	117.7	114.4	120.3	116.9
11 years	126.6	128.2	127.8	128.9	127.2	129.1	129.0	129.8
Male standard								
Boys	Standard error of the mean							
6 years	3.21	2.05	1.40	1.14	0.84	2.44	1.84	1.47
11 years	2.13	1.91	2.09	1.10	0.83	1.89	1.74	1.83
Girls								
6 years	3.30	1.90	1.38	1.82	0.69	1.34	2.43	2.76
11 years	2.77	2.35	1.73	1.43	1.17	2.47	1.76	2.52
Male standard								
Actual mean	Mean skeletal age in months							
Boys: 6-11 years	99.3	100.6	102.7	99.0	99.4	102.1	100.6	101.9
Girls: 6-11 years	118.7	120.3	120.9	119.2	119.3	116.0	121.8	119.4
Expected mean								
Boys: 6-11 years	101.3	100.9	102.3	99.3	99.4	100.3	99.6	101.7
Girls: 6-11 years	120.4	121.4	121.5	118.9	119.1	115.2	120.4	118.8
	Standard error of the mean							
Boys: 6-11 years	1.15	1.54	0.84	0.73	0.50	1.16	0.79	1.03
Girls: 6-11 years	2.05	1.29	1.17	0.89	0.80	1.50	1.30	1.84

Table 8. Selected percentiles in the distribution of skeletal age (hand-wrist) for boys and girls, by race, geographic region, annual family income, and chronological age at last birthday: United States, 1963-65

Race, region, annual family income, and percentile	Chronological age in years at last birthday					
	Boys					
	6 years	7 years	8 years	9 years	10 years	11 years
	Skeletal age in months					
White						
75	82.9	94.9	106.6	113.6	120.3	131.2
50	75.1	86.8	97.6	107.6	113.7	121.0
25	67.8	79.1	88.9	98.7	108.4	115.2
Negro						
75	85.8	95.0	108.5	114.9	118.8	133.3
50	79.9	88.2	105.1	107.9	112.6	123.9
25	72.4	79.2	93.3	99.1	107.6	117.1
Northeast						
75	84.4	97.6	108.4	115.2	121.8	134.3
50	77.2	87.5	99.2	109.4	113.9	125.0
25	69.8	79.8	89.7	98.5	108.8	118.2
Midwest						
75	85.0	98.9	105.9	114.9	120.4	129.9
50	76.3	87.3	98.4	108.9	114.3	123.0
25	67.3	81.9	89.7	101.8	108.4	114.7
South						
75	81.9	91.8	107.8	112.6	121.4	129.3
50	74.3	87.4	98.5	107.4	113.8	121.4
25	69.3	77.5	90.7	99.1	107.8	114.6
West						
75	83.5	94.3	106.2	111.6	116.5	131.5
50	75.5	86.0	96.7	105.0	112.7	119.6
25	68.1	78.3	88.6	96.1	108.1	115.4
Less than $5,000						
75	83.9	94.0	107.3	111.7	120.3	133.8
50	74.6	86.6	97.9	106.2	113.1	123.0
25	69.1	77.5	89.8	97.0	107.8	115.6
$5,000-$9,999						
75	84.3	96.4	107.0	114.4	120.6	130.4
50	76.7	87.2	98.1	108.1	114.1	120.7
25	68.7	79.7	89.2	99.7	109.0	115.4
$10,000 or more						
75	82.4	94.6	106.9	114.8	118.1	131.0
50	74.9	88.0	99.3	109.5	112.5	123.0
25	67.3	81.7	89.7	103.4	106.5	117.2

Table 8. Selected percentiles in the distribution of skeletal age (hand-wrist) for boys and girls, by race, geographic region, annual family income, and chronological age at last birthday: United States, 1963-65—Con.

Race, region, annual family income, and percentile	Chronological age in years at last birthday											
	Girls (male standard)						Girls (female equivalent)					
	6 years	7 years	8 years	9 years	10 years	11 years	6 years	7 years	8 years	9 years	10 years	11 years
	Skeletal age in months											
White												
75	98.6	110.6	118.1	129.3	152.9	166.5	85.6	95.8	103.1	112.2	125.9	134.8
50	89.4	103.6	112.6	119.9	135.3	159.5	76.4	89.6	97.6	104.9	115.6	129.8
25	81.6	92.6	106.4	114.2	124.0	149.4	67.6	79.6	92.4	99.2	108.5	123.7
Negro												
75	102.8	113.0	117.4	131.8	156.8	170.6	88.9	98.0	102.4	113.4	128.4	138.6
50	93.1	106.8	111.2	121.0	141.5	160.5	80.1	92.8	96.2	106.0	119.2	130.2
25	83.0	93.3	106.1	115.9	127.1	148.0	69.5	80.3	92.1	100.9	110.6	123.0
Northeast												
75	99.0	112.4	118.4	138.4	154.1	166.5	86.0	97.4	103.4	117.4	126.6	134.8
50	91.5	106.5	112.8	123.9	135.3	160.5	78.5	92.5	97.8	108.4	115.6	130.2
25	82.5	96.1	107.5	117.0	122.7	150.6	68.8	83.1	93.5	102.0	107.7	124.3
Midwest												
75	104.7	110.4	119.6	128.4	153.5	166.0	90.7	95.7	104.6	111.4	126.2	134.5
50	93.3	104.2	114.2	120.4	141.2	158.6	80.3	90.2	99.2	105.4	119.1	129.3
25	83.6	93.3	107.3	115.4	125.8	145.0	70.4	80.3	93.3	100.4	109.8	121.0
South												
75	97.2	110.6	116.0	128.9	154.5	166.9	84.2	95.8	101.0	111.9	126.8	134.9
50	88.9	103.1	110.3	119.4	135.0	160.1	75.9	89.1	95.6	104.4	115.5	130.0
25	80.3	90.4	104.6	113.4	124.8	146.0	66.3	77.4	90.6	98.4	108.9	122.0
West												
75	96.4	109.7	118.8	126.6	152.4	168.1	83.4	95.4	103.8	110.3	125.4	136.1
50	86.2	99.7	111.5	117.1	134.2	160.3	73.2	86.7	96.5	102.1	115.1	130.2
25	80.4	91.2	103.9	111.8	123.4	150.7	66.4	78.2	89.9	96.8	108.2	124.4
Less than $5,000												
75	100.8	110.5	117.6	127.4	154.2	167.1	87.8	95.8	102.6	110.7	126.6	135.1
50	89.4	104.4	111.2	118.4	136.3	160.2	76.4	90.4	96.2	103.4	116.2	130.1
25	80.9	91.6	104.8	112.9	122.5	148.6	66.9	78.6	90.8	97.9	107.5	123.3
$5,000-$9,999												
75	98.5	111.2	118.6	131.3	153.0	167.6	85.5	96.2	103.6	113.2	126.0	135.6
50	91.0	103.7	113.2	121.1	134.1	159.8	78.0	89.7	98.2	106.1	115.0	129.9
25	82.3	93.5	107.1	114.7	124.9	149.2	68.4	80.5	93.1	99.7	108.9	123.6
$10,000 or more												
75	97.7	112.3	117.2	131.6	153.9	166.5	84.7	97.3	102.2	113.3	126.4	134.8
50	89.6	105.5	112.4	123.8	138.3	158.4	76.6	91.5	97.4	108.4	117.3	129.2
25	81.4	91.5	106.3	116.0	127.1	149.0	67.4	78.5	92.3	101.0	110.6	123.5

Table 9. Mean bone-specific skeletal ages for the 31 individual hand-wrist bones of white and Negro boys and girls, by chronological age at last birthday, with selected standard errors: United States, 1963-65

Standard of reference, sex, and chronological age at last birthday	Radius		Ulna		Capitate		Hamate		Triquetral	
	White	Negro	White	Negro	White	Negro	White	Negro	White	Negro
Male standard										
Boys	Mean skeletal age in months									
6 years	74.1	79.7	85.1	89.1	75.3	80.9	74.9	81.8	73.1	78.2
7 years	85.2	87.9	90.9	92.9	86.1	88.3	85.4	88.3	85.6	89.7
8 years	94.9	100.2	96.8	100.1	95.4	101.1	94.6	101.5	96.2	102.6
9 years	105.8	108.8	104.9	108.0	104.8	108.6	104.2	109.2	106.1	110.0
10 years	113.9	112.9	113.1	110.4	114.2	114.1	114.4	115.2	114.3	114.2
11 years	123.8	126.4	123.1	125.2	124.2	126.9	125.3	129.0	123.7	126.1
Girls										
6 years	84.7	89.3	89.6	95.6	87.1	92.4	86.4	93.5	88.8	94.7
7 years	96.6	100.6	98.0	101.1	98.8	104.1	98.7	104.7	101.3	105.8
8 years	107.9	109.8	107.0	108.2	109.9	111.2	109.9	111.7	110.9	112.1
9 years	118.1	124.0	118.3	122.8	120.0	124.8	121.6	127.2	120.3	124.2
10 years	133.4	139.4	132.3	137.5	135.7	141.1	137.6	143.7	133.3	138.6
11 years	153.8	156.4	151.2	154.2	154.3	155.3	154.8	157.6	150.2	152.0
Female equivalent										
Girls										
6 years	76.8	81.3	86.3	87.6	75.1	80.4	74.4	80.8	75.8	81.7
7 years	87.8	91.3	87.9	88.3	85.8	90.1	85.0	90.7	87.3	91.8
8 years	94.9	95.9	93.0	94.1	95.9	96.6	95.9	97.4	95.9	97.1
9 years	103.1	108.0	103.3	107.4	105.0	108.8	106.6	110.2	105.2	107.2
10 years	114.4	118.0	113.0	116.5	115.8	119.6	116.8	120.8	114.3	117.6
11 years	126.9	128.7	125.2	127.2	127.3	128.2	127.8	129.6	124.6	125.5
Male standard										
Boys	Standard error of the mean									
6 years	0.75	2.06	0.74	2.31	0.69	1.65	0.65	1.70	1.07	3.11
11 years	0.55	0.82	0.61	0.82	0.69	0.73	0.68	0.99	0.55	1.05
Girls										
6 years	0.71	2.15	0.54	1.69	0.68	1.90	0.55	1.88	0.61	1.87
11 years	0.63	1.05	0.55	1.52	0.79	1.37	0.63	1.27	0.65	1.61
Actual values	Mean skeletal age in months									
Boys: 6-11 years	99.3	102.2	105.9	106.7	99.7	102.9	99.5	103.7	99.7	103.2
Girls: 6-11 years	115.3	119.0	117.2	120.9	116.8	120.1	117.4	121.7	116.4	119.8
Expected values										
Boys: 6-11 years	99.8	99.6	106.2	105.3	100.2	100.0	100.1	100.0	100.2	100.0
Girls: 6-11 years	115.9	115.5	117.8	117.7	117.4	116.8	118.2	117.5	117.0	116.5
	Standard error of the mean									
Boys: 6-11 years	0.30	0.76	0.23	0.62	0.26	0.69	0.26	0.79	0.29	1.00
Girls: 6-11 years	0.26	0.98	0.33	0.66	0.32	0.77	0.26	0.74	0.22	0.76

Table 9. Mean bone-specific skeletal ages for the 31 individual hand-wrist bones of white and Negro boys and girls, by chronological age at last birthday, with selected standard errors: United States, 1963-65—Con.

Standard of reference, sex, and chronological age at last birthday	Lunate		Scaphoid		Trapezium		Trapezoid		Metacarpal I	
	White	Negro	White	Negro	White	Negro	White	Negro	White	Negro
Male standard										
Boys	Mean skeletal age in months									
6 years	69.7	73.1	82.6	87.8	76.7	77.3	79.8	84.8	70.6	78.6
7 years	82.7	82.9	90.6	92.8	82.9	85.6	87.7	89.6	83.3	86.1
8 years	94.1	98.8	98.4	103.6	91.4	98.6	96.2	101.8	93.2	100.9
9 years	105.1	107.4	106.4	109.9	101.3	105.0	105.8	108.0	104.0	105.7
10 years	114.5	114.7	114.1	114.1	109.6	111.9	113.2	112.5	111.8	112.4
11 years	124.7	127.7	123.5	128.0	120.9	124.8	122.6	126.0	122.6	125.7
Girls										
6 years	84.6	87.9	93.4	99.8	88.5	93.3	90.0	95.0	89.6	96.6
7 years	96.9	101.0	102.7	107.0	98.6	104.4	101.3	106.2	101.0	105.9
8 years	109.0	110.0	111.6	111.7	108.9	111.0	110.2	111.9	110.7	112.9
9 years	119.2	125.4	120.0	125.4	118.0	124.0	119.2	123.5	121.5	125.8
10 years	132.9	138.3	132.4	138.5	132.4	138.2	132.8	136.5	136.3	141.6
11 years	150.4	153.0	150.1	151.2	151.6	153.2	150.6	152.3	155.3	155.5
Female equivalent										
Girls										
6 years	69.6	72.9	76.4	82.9	82.2	84.4	77.0	83.0	74.6	81.6
7 years	84.9	91.5	85.8	92.0	86.3	90.7	89.3	92.2	86.0	91.9
8 years	98.4	98.6	96.6	96.7	94.9	96.5	95.6	96.9	96.8	98.9
9 years	104.2	110.2	104.0	109.4	103.0	108.0	104.2	107.8	106.5	109.4
10 years	113.9	117.3	113.2	117.5	113.7	117.1	113.9	116.2	116.2	120.3
11 years	124.7	126.5	124.6	125.1	125.3	126.2	124.8	126.3	128.2	128.2
Male standard										
Boys	Standard error of the mean									
6 years	1.05	2.28	0.69	1.16	0.70	1.67	0.47	1.06	0.78	1.51
11 years	0.64	1.29	0.51	1.19	0.74	0.66	0.60	0.78	0.63	0.79
Girls										
6 years	1.00	2.44	0.57	1.48	0.68	2.01	0.45	1.56	0.71	1.64
11 years	0.70	1.56	0.68	1.52	0.69	1.37	0.72	1.55	0.68	2.05
Actual values	Mean skeletal age in months									
Boys: 6-11 years	98.8	100.8	104.5	107.1	99.6	102.1	102.7	105.0	97.3	101.2
Girls: 6-11 years	114.8	118.0	118.1	121.6	115.9	119.6	116.8	119.8	118.6	122.0
Expected values										
Boys: 6-11 years	99.1	98.8	105.0	104.2	100.2	99.1	103.1	102.6	97.9	97.7
Girls: 6-11 years	115.4	114.8	118.7	118.3	116.6	115.9	117.4	116.7	119.2	118.6
	Standard error of the mean									
Boys: 6-11 years	0.38	0.86	0.25	0.84	0.35	0.71	0.29	0.60	0.27	0.66
Girls: 6-11 years	0.26	0.78	0.18	0.49	0.22	0.65	0.21	0.67	0.26	0.68

Table 9. Mean bone-specific skeletal ages for the 31 individual hand-wrist bones of white and Negro boys and girls, by chronological age at last birthday, with selected standard errors: United States, 1963-65—Con.

Standard of reference, sex, and chronological age at last birthday	Metacarpal II		Metacarpal III		Metacarpal IV		Metacarpal V		Pisiform	
	White	Negro	White	Negro	White	Negro	White	Negro	White	Negro
Male standard										
Boys	Mean skeletal age in months									
6 years	74.2	80.2	73.9	80.5	73.0	80.6	72.5	80.3	115.0	134.0
7 years	86.1	87.6	85.9	87.8	85.5	88.1	85.2	88.7	112.1	113.8
8 years	94.9	100.7	94.8	100.7	94.4	100.8	94.5	100.8	115.7	114.4
9 years	105.1	106.2	104.9	106.1	104.7	105.7	104.6	105.6	117.5	117.0
10 years	112.7	112.1	112.4	112.5	112.1	112.5	112.1	112.6	119.2	117.0
11 years	122.4	124.7	122.7	125.4	122.2	125.4	122.6	125.5	126.9	126.0
Girls										
6 years	89.2	92.4	89.2	92.2	88.7	92.3	88.7	91.6	116.6	116.7
7 years	101.3	104.2	101.2	104.0	100.8	104.0	100.4	103.9	117.1	116.5
8 years	110.6	111.9	110.5	112.1	110.1	112.1	110.0	112.5	119.7	123.5
9 years	120.7	125.6	120.8	126.0	120.7	126.2	121.3	126.4	125.4	129.7
10 years	135.0	141.8	135.8	142.5	135.6	142.6	137.2	143.3	137.9	141.4
11 years	153.9	155.3	154.8	156.2	154.9	156.3	156.3	157.0	153.9	153.3
Female equivalent										
Girls										
6 years	74.2	77.4	74.6	78.2	73.7	77.3	73.7	76.6	102.8	102.8
7 years	86.3	89.8	87.2	90.0	85.9	90.0	85.4	88.9	103.1	102.8
8 years	95.6	96.9	96.5	98.1	95.1	97.1	95.0	97.5	104.8	107.8
9 years	105.7	109.3	105.8	110.0	105.7	109.6	106.2	109.4	109.4	111.8
10 years	115.5	119.4	115.8	120.2	115.8	119.8	116.2	119.8	116.9	119.2
11 years	127.4	128.2	127.9	128.6	127.9	128.6	128.6	129.0	126.9	126.6
Male standard										
Boys	Standard error of the mean									
6 years	0.86	1.75	0.88	1.77	0.83	1.74	0.84	2.14	81.31	94.75
11 years	0.52	0.95	0.54	0.82	0.52	0.80	0.61	0.79	0.72	2.03
Girls										
6 years	0.73	1.99	0.75	1.92	0.69	2.05	0.76	2.22	1.96	26.18
11 years	0.69	1.27	0.68	1.40	0.72	1.37	0.67	1.29	0.63	2.29
Actual values	Mean skeletal age in months									
Boys: 6-11 years	99.0	101.5	98.8	101.8	98.4	101.8	98.3	101.9	122.5	121.9
Girls: 6-11 years	118.0	121.0	118.3	121.2	118.0	121.3	118.5	121.5	134.7	138.0
Expected values										
Boys: 6-11 years	99.4	99.2	99.3	99.1	98.9	98.7	98.8	98.7	122.5	122.8
Girls: 6-11 years	118.5	118.1	118.8	118.4	118.6	118.1	119.0	118.5	135.0	136.1
	Standard error of the mean									
Boys: 6-11 years	0.32	0.72	0.31	0.67	0.31	0.68	0.32	0.73	0.45	1.32
Girls: 6-11 years	0.24	0.79	0.25	0.76	0.23	0.82	0.25	0.85	0.40	1.39

Table 9. Mean bone-specific skeletal ages for the 31 individual hand-wrist bones of white and Negro boys and girls, by chronological age at last birthday, with selected standard errors: United States, 1963-65—Con.

Standard of reference, sex, and chronological age at last birthday	Adductor sesamoid		Flexor sesamoid		Proximal phalanx I		Proximal phalanx II		Proximal phalanx III	
	White	Negro	White	Negro	White	Negro	White	Negro	White	Negro
Male standard										
Boys	Mean skeletal age in months									
6 years	---	---	---	---	76.0	78.9	78.6	79.4	78.1	78.3
7 years	---	---	---	---	87.2	88.4	90.1	88.0	89.4	87.3
8 years	---	---	---	---	96.3	99.1	98.8	99.4	98.4	99.1
9 years	155.0	---	159.6	---	105.1	103.9	107.3	103.4	107.0	103.7
10 years	157.5	164.0	158.0	---	113.6	110.8	114.8	110.7	114.9	110.7
11 years	156.1	159.2	161.5	158.2	124.3	126.7	124.9	125.8	125.0	125.4
Girls										
6 years	152.0	---	---	---	89.8	90.4	92.7	91.1	92.1	91.2
7 years	154.6	---	160.0	---	100.6	101.9	103.6	102.3	103.2	102.0
8 years	154.6	154.6	160.7	158.0	112.6	113.4	114.1	112.1	113.9	112.3
9 years	155.6	160.3	161.2	162.0	125.8	128.8	125.6	125.9	125.6	125.7
10 years	158.2	159.6	161.8	163.5	141.1	146.2	141.1	144.8	141.3	145.3
11 years	162.4	165.7	165.3	168.5	160.3	161.4	160.5	159.9	160.6	160.2
Female equivalent										
Girls										
6 years	125.5	---	---	---	74.9	75.4	77.7	76.1	77.1	76.2
7 years	127.6	---	131.0	---	85.6	86.9	88.6	87.3	88.2	87.0
8 years	127.6	127.6	131.4	130.0	98.6	99.4	99.1	97.1	98.9	97.3
9 years	128.3	131.2	131.6	132.0	109.4	111.8	108.6	108.9	109.3	109.4
10 years	130.8	130.8	131.9	133.2	119.0	122.1	119.1	121.4	119.2	121.6
11 years	132.4	134.4	134.2	136.5	130.6	131.4	130.8	130.4	132.6	132.2
Male standard										
Boys	Standard error of the mean									
6 years	---	---	---	---	0.68	1.13	0.67	1.25	0.69	1.20
11 years	0.63	3.21	1.26	0.17	0.74	1.20	0.68	1.24	0.70	1.26
Girls										
6 years	107.48	---	---	---	0.69	1.73	0.78	1.67	0.81	1.75
11 years	0.31	1.27	0.44	1.42	0.69	2.05	0.64	1.71	0.63	1.82
Actual values	Mean skeletal age in months									
Boys: 6-11 years	156.1	159.5	161.1	158.2	100.2	100.9	102.2	100.7	101.9	100.3
Girls: 6-11 years	160.2	162.5	164.0	166.0	121.2	122.5	122.4	121.6	122.3	121.7
Expected values										
Boys: 6-11 years	156.6	156.7	160.7	161.0	100.3	100.1	102.0	101.8	101.7	101.5
Girls: 6-11 years	160.7	160.3	164.4	164.2	121.5	120.8	122.4	121.9	122.3	121.7
	Standard error of the mean									
Boys: 6-11 years	0.51	2.98	1.16	0.17	0.36	0.38	0.32	0.52	0.33	0.52
Girls: 6-11 years	0.27	0.71	0.39	1.13	0.36	0.93	0.35	0.80	0.36	0.84

Table 9. Mean bone-specific skeletal ages for the 31 individual hand-wrist bones of white and Negro boys and girls, by chronological age at last birthday, with selected standard errors: United States, 1963-65—Con.

Standard of reference, sex, and chronological age at last birthday	Proximal phalanx IV		Proximal phalanx V		Middle phalanx II		Middle phalanx III		Middle phalanx IV	
	White	Negro	White	Negro	White	Negro	White	Negro	White	Negro
Male standard										
Boys	Mean skeletal age in months									
6 years	77.2	77.5	77.7	78.4	80.7	81.3	78.9	80.3	79.2	81.3
7 years	89.3	86.8	89.8	88.1	91.4	90.7	89.7	89.8	90.7	89.9
8 years	98.4	99.0	99.0	100.0	99.9	102.7	98.8	101.6	99.4	102.1
9 years	107.1	103.7	107.2	105.0	108.4	106.8	107.7	106.2	107.4	107.0
10 years	115.5	111.9	115.4	112.1	115.8	113.2	115.3	112.8	114.9	112.1
11 years	125.6	125.6	125.7	127.0	126.6	127.1	126.2	127.4	125.2	125.9
Girls										
6 years	91.8	91.0	92.2	91.9	93.8	93.2	92.4	92.0	93.0	92.4
7 years	103.3	102.1	103.4	102.4	103.5	103.3	102.6	102.7	102.8	102.7
8 years	114.3	112.2	114.6	113.2	114.6	113.1	113.7	112.1	113.3	111.7
9 years	126.0	125.9	126.1	127.0	126.0	126.9	125.6	126.2	124.7	125.6
10 years	141.4	145.3	141.6	145.8	141.3	143.7	141.0	143.7	140.0	142.4
11 years	160.8	160.6	160.9	160.6	160.1	160.5	160.0	160.9	159.4	160.4
Female equivalent										
Girls										
6 years	76.8	76.0	77.2	76.9	78.8	78.2	77.7	77.5	78.0	77.7
7 years	88.3	87.1	88.4	87.4	89.5	89.3	88.6	88.7	88.8	88.7
8 years	99.3	97.2	100.6	99.2	100.4	98.2	99.4	97.1	98.6	96.7
9 years	109.5	109.4	109.6	110.0	109.5	109.9	109.3	109.6	108.7	109.3
10 years	119.2	121.6	119.5	121.6	119.2	120.7	119.0	120.7	118.5	119.1
11 years	132.8	132.6	131.4	131.3	131.0	131.2	131.0	131.3	130.7	131.7
Male standard										
Boys	Standard error of the mean									
6 years	0.74	1.40	0.76	1.60	0.59	1.17	0.63	1.33	0.64	1.39
11 years	0.70	1.15	0.66	1.37	0.60	0.93	0.63	0.86	0.61	0.98
Girls										
6 years	0.82	1.68	0.83	2.05	0.80	1.50	0.76	1.57	0.73	1.55
11 years	0.70	1.79	0.64	1.83	0.70	2.09	0.70	1.75	0.75	1.73
Actual values	Mean skeletal age in months									
Boys: 6-11 years	101.9	100.3	102.2	101.3	103.5	103.2	102.5	102.5	102.6	102.6
Girls: 6-11 years	122.4	121.7	122.6	122.4	122.7	122.4	122.1	121.9	121.7	121.5
Expected values										
Boys: 6-11 years	101.7	101.5	102.1	101.9	103.6	103.3	102.6	102.3	102.6	102.4
Girls: 6-11 years	122.4	121.8	122.6	122.1	122.8	122.3	122.2	121.7	121.8	121.3
	Standard error of the mean									
Boys: 6-11 years	0.37	0.55	0.37	0.71	0.28	0.66	0.29	0.52	0.30	0.57
Girls: 6-11 years	0.37	0.86	0.34	0.91	0.30	0.92	0.30	0.92	0.33	0.93

Table 9. Mean bone-specific skeletal ages for the 31 individual hand-wrist bones of white and Negro boys and girls, by chronological age at last birthday, with selected standard errors: United States, 1963-65—Con.

Standard of reference, sex, and chronological age at last birthday	Middle phalanx V		Distal phalanx I		Distal phalanx II		Distal phalanx III		Distal phalanx IV		Distal phalanx V	
	White	Negro	White	Negro	White	Negro	White	Negro	White	Negro	White	Negro
Male standard												
Boys	Mean skeletal age in months											
6 years	78.7	79.8	73.9	75.7	76.3	81.0	75.5	80.7	75.0	80.2	75.4	80.1
7 years	90.3	89.2	86.9	88.9	89.2	92.9	88.9	92.5	88.8	92.1	88.6	92.4
8 years	99.3	102.8	98.7	101.6	99.7	105.0	99.4	104.9	99.4	104.7	99.2	104.5
9 years	107.7	107.2	107.7	106.9	108.2	108.5	108.1	108.7	108.1	109.0	108.1	108.8
10 years	115.2	112.2	115.2	112.5	115.5	113.2	115.6	113.3	115.5	113.3	115.4	113.4
11 years	125.8	127.0	125.6	127.2	125.2	126.0	125.3	126.3	125.4	126.4	125.6	127.4
Girls												
6 years	93.4	92.6	90.9	91.0	93.3	94.5	92.8	94.1	92.6	94.1	92.7	93.8
7 years	103.0	102.4	102.2	102.0	103.9	104.6	103.6	104.4	103.6	104.1	103.4	104.3
8 years	113.7	111.7	113.2	112.0	112.8	113.0	112.8	112.1	112.8	111.9	112.6	111.9
9 years	125.2	125.5	124.6	126.1	123.6	124.8	123.5	125.4	123.5	125.6	123.4	125.5
10 years	140.5	142.6	139.6	141.5	138.0	138.7	138.2	139.8	138.5	140.0	138.6	140.7
11 years	160.0	160.8	158.8	157.6	157.3	156.2	157.4	156.6	157.9	157.2	158.3	157.3
Female equivalent												
Girls												
6 years	74.8	74.3	74.9	75.0	78.3	79.5	78.7	80.1	78.4	80.1	77.7	78.8
7 years	89.0	88.4	87.2	87.0	88.9	89.6	89.9	91.2	89.9	91.0	88.4	89.3
8 years	98.7	96.7	98.2	97.0	97.8	98.0	98.8	98.1	98.8	97.9	97.6	96.9
9 years	108.2	108.5	107.8	109.1	107.8	108.8	107.8	109.4	107.8	109.6	107.7	109.2
10 years	118.5	119.8	117.8	119.2	117.0	117.7	117.2	118.8	117.5	119.0	117.6	118.8
11 years	130.6	130.9	130.4	129.6	129.3	128.6	129.4	128.8	129.9	129.2	130.3	129.3
Male standard												
Boys	Standard error of the mean											
6 years	0.67	1.35	0.70	1.50	0.73	1.13	0.72	1.32	0.78	1.37	0.75	1.43
11 years	0.66	0.95	0.66	1.11	0.64	0.98	0.65	0.95	0.65	0.96	0.66	0.98
Girls												
6 years	0.77	1.70	0.73	1.72	0.72	1.42	0.74	1.52	0.80	1.49	0.72	1.62
11 years	0.73	2.10	0.60	1.95	0.71	2.06	0.70	1.95	0.73	2.02	0.69	2.10
Actual values	Mean skeletal age in months											
Boys: 6-11 years	102.6	102.6	101.0	101.7	102.1	104.0	101.9	104.0	101.8	103.8	101.8	104.0
Girls: 6-11 years	122.1	121.6	120.8	120.4	120.8	120.8	120.7	120.9	120.8	121.0	120.8	120.9
Expected values												
Boys: 6-11 years	102.7	102.4	101.2	101.0	102.4	102.2	102.2	102.0	102.2	101.9	102.2	101.9
Girls: 6-11 years	122.1	121.8	120.9	120.3	120.9	120.4	120.8	120.3	121.0	120.4	121.0	120.3
	Standard error of the mean											
Boys: 6-11 years	0.31	0.60	0.34	0.63	0.32	0.63	0.33	0.70	0.33	0.69	0.35	0.67
Girls: 6-11 years	0.31	0.97	0.32	0.84	0.30	0.79	0.30	0.78	0.30	0.80	0.33	0.81

Table 10. Mean bone-specific skeletal ages for the 31 individual hand-wrist bones of boys and girls, by geographic region and chronological age at last birthday, with selected standard errors: United States, 1963-65

Standard of reference, sex, and chronological age at last birthday	Radius				Ulna				Capitate			
	Northeast	Midwest	South	West	Northeast	Midwest	South	West	Northeast	Midwest	South	West
Male standard												
Boys	Mean skeletal age in months											
6 years	75.0	74.8	75.2	74.8	83.4	84.9	88.0	87.1	76.9	75.0	75.5	77.1
7 years	87.3	85.9	84.3	84.9	89.7	92.9	90.2	91.4	87.5	87.8	84.6	85.8
8 years	96.7	94.4	98.0	94.3	97.7	97.2	96.8	97.6	97.2	95.2	98.5	94.6
9 years	107.0	106.4	107.0	104.4	106.0	105.7	105.8	103.8	105.7	105.8	106.2	103.6
10 years	114.2	113.9	114.1	112.8	113.3	113.8	112.1	111.5	115.1	114.5	114.4	112.8
11 years	127.4	123.8	122.8	123.3	126.4	122.7	122.2	122.7	128.4	123.2	123.5	124.0
Girls												
6 years	85.7	87.9	85.3	82.8	90.3	92.7	90.5	88.4	88.4	91.0	87.5	85.0
7 years	98.8	97.2	96.3	96.4	99.8	99.2	96.3	97.9	100.5	100.6	98.1	98.8
8 years	108.4	108.6	108.6	107.3	107.7	107.8	106.7	106.6	110.6	110.6	109.5	109.4
9 years	124.8	117.1	118.8	116.2	123.1	118.6	119.1	115.3	125.2	120.9	120.5	117.0
10 years	134.7	134.6	135.2	133.0	132.7	133.5	133.2	132.8	136.2	137.2	136.5	135.8
11 years	155.6	152.0	153.6	156.6	153.2	150.3	150.5	153.6	154.3	153.2	153.7	157.4
Female equivalent												
Girls												
6 years	78.0	79.9	77.4	75.9	86.6	87.1	86.8	84.6	76.4	79.0	75.5	72.5
7 years	90.4	88.3	87.6	87.7	88.2	88.0	87.7	87.9	87.5	87.6	85.1	85.8
8 years	95.2	95.3	95.3	94.6	93.7	93.8	92.8	92.8	96.3	96.3	95.5	95.4
9 years	108.8	102.1	103.8	101.2	107.6	103.6	104.1	99.4	109.1	10.59	105.5	102.5
10 years	115.4	115.3	115.6	114.0	113.4	113.8	113.6	113.4	116.2	117.1	116.5	115.9
11 years	128.3	126.0	126.8	128.8	126.6	124.6	124.7	126.8	127.3	126.6	126.8	129.4
Male standard												
Boys	Standard error of the mean											
6 years	1.50	1.43	1.05	1.21	0.96	2.18	2.12	1.41	0.64	0.99	1.02	1.48
11 years	0.97	0.63	0.71	1.27	1.00	0.95	0.48	1.72	1.21	1.06	0.71	2.36
Girls												
6 years	0.76	1.02	1.45	1.25	0.70	0.85	0.62	1.24	0.30	1.06	1.25	1.34
11 years	1.97	1.07	0.93	1.97	2.22	1.06	0.84	2.05	2.18	0.81	1.11	2.40
Actual values	Mean skeletal age in months											
Boys: 6-11 years	100.8	100.3	99.1	98.8	106.4	106.6	105.7	105.5	101.4	100.7	99.3	99.4
Girls: 6-11 years	115.6	116.4	117.1	114.1	117.1	118.4	118.8	116.6	116.5	118.8	118.0	115.6
Expected values												
Boys: 6-11 years	99.7	100.5	98.9	99.8	105.8	106.3	106.1	106.0	100.1	100.9	99.3	100.2
Girls: 6-11 years	114.0	116.7	117.2	115.2	115.9	118.1	119.5	117.5	115.4	118.2	118.6	116.8
	Standard error of the mean											
Boys: 6-11 years	0.74	0.39	0.38	0.71	0.48	0.37	0.43	0.80	0.72	0.45	0.41	1.00
Girls: 6-11 years	0.76	1.17	1.16	1.06	0.94	0.91	0.71	1.28	0.84	1.06	1.07	1.19

Table 10. Mean bone-specific skeletal ages for the 31 individual hand-wrist bones of boys and girls, by geographic region and chronological age at last birthday, with selected standard errors: United States, 1963-65—Con.

Standard of reference, sex, and chronological age at last birthday	Hamate				Triquetral				Lunate				Scaphoid			
	North-east	Mid-west	South	West	North-east	Mid-west	South	West	North-east	Mid-west	South	West	North-east	Mid-west	South	West
Male standard																
Boys	Mean skeletal age in months															
6 years	77.1	74.2	75.4	77.0	75.5	71.9	73.4	74.7	71.6	69.6	68.6	71.5	83.1	82.0	82.9	86.0
7 years	87.0	87.0	84.6	84.6	86.9	87.2	84.8	85.6	82.5	85.4	81.8	80.8	91.3	93.6	89.3	89.4
8 years	97.0	94.2	97.8	94.0	97.3	96.3	99.5	95.7	94.6	93.6	97.1	94.0	98.3	98.5	101.3	98.8
9 years	105.9	104.7	105.9	103.4	106.7	106.3	108.0	105.5	105.1	106.8	105.9	103.9	105.7	107.8	108.1	105.8
10 years	115.2	115.1	115.1	112.7	114.8	114.5	114.9	112.9	114.0	115.0	114.8	114.1	114.7	114.0	114.7	113.2
11 years	129.7	124.9	125.4	124.2	127.0	123.4	123.4	123.0	128.2	124.1	124.4	124.2	127.3	123.7	122.6	123.6
Girls																
6 years	88.3	89.6	87.0	85.2	90.0	92.9	88.6	87.0	86.0	90.2	82.1	81.9	95.4	97.1	92.6	92.6
7 years	100.4	100.5	98.2	98.5	103.1	102.5	100.7	101.6	99.8	98.3	94.7	97.0	103.7	103.5	102.7	103.2
8 years	110.3	111.4	109.2	109.5	111.1	112.2	110.3	110.7	108.0	111.0	107.9	109.4	112.2	112.1	110.4	111.7
9 years	126.4	123.0	122.2	118.4	124.3	121.1	120.8	118.0	124.2	120.8	119.3	116.6	124.8	120.0	120.7	118.1
10 years	137.6	139.8	138.4	137.4	134.2	135.6	133.2	132.9	133.8	135.0	133.1	132.7	133.8	134.2	132.7	132.7
11 years	155.6	154.2	154.9	156.8	150.6	149.6	149.7	152.8	151.6	148.3	151.0	153.1	151.0	148.6	150.2	152.0
Female equivalent																
Girls																
6 years	76.3	77.6	75.0	73.2	77.0	79.9	75.6	74.0	71.0	75.2	67.1	66.9	78.4	80.2	75.6	75.6
7 years	86.6	87.8	85.1	85.2	89.1	88.5	86.7	87.6	89.7	87.4	82.0	85.0	87.0	86.8	85.8	86.3
8 years	96.3	97.2	95.2	95.5	96.1	97.2	95.3	95.7	98.2	98.8	98.2	98.5	97.2	97.1	95.7	96.7
9 years	109.7	107.5	107.1	103.4	107.3	105.6	105.4	103.0	109.2	105.8	104.3	101.6	108.9	104.0	105.0	103.0
10 years	116.8	118.4	117.4	116.7	115.1	115.8	114.2	113.9	114.8	115.5	114.1	113.8	113.9	114.2	113.6	113.6
11 years	128.3	127.2	127.9	128.9	124.8	124.3	124.4	125.9	125.6	123.3	125.0	126.6	125.0	123.6	124.6	125.5
Male standard																
Boys	Standard error of the mean															
6 years	0.58	1.04	1.02	1.54	1.44	1.96	1.29	2.25	1.18	1.34	2.68	1.76	1.43	1.54	0.99	1.32
11 years	1.22	1.06	0.69	1.91	1.11	0.81	0.80	1.36	1.27	1.05	0.94	2.14	1.04	0.72	0.99	1.51
Girls																
6 years	0.47	1.33	1.08	0.97	0.46	1.20	1.04	0.98	0.88	1.52	1.36	1.75	1.18	0.84	1.32	0.96
11 years	1.94	0.71	0.67	1.93	2.23	1.25	1.09	1.86	2.21	1.02	0.70	1.92	2.22	1.29	0.85	2.00
Actual values	Mean skeletal age in months															
Boys: 6-11 years	101.6	100.5	99.5	99.0	101.1	100.6	99.7	99.4	99.5	100.3	98.1	98.3	105.2	105.7	104.3	104.3
Girls: 6-11 years	117.1	119.8	118.8	116.2	115.8	118.7	117.2	115.5	114.8	117.2	115.3	113.6	118.4	119.5	119.0	117.5
Expected values																
Boys: 6-11 years	100.0	100.9	99.3	100.1	100.0	101.0	99.4	100.1	98.9	100.0	98.2	99.0	104.8	105.5	104.2	104.8
Girls: 6-11 years	116.2	119.0	119.4	117.5	114.9	117.8	118.1	116.5	113.6	116.1	116.7	114.7	117.2	119.3	119.7	118.2
	Standard error of the mean															
Boys: 6-11 years	0.62	0.49	0.49	0.94	0.98	0.62	0.48	0.94	0.73	0.59	0.84	1.39	0.72	0.38	0.50	1.17
Girls: 6-11 years	0.77	0.99	0.95	1.09	0.81	1.02	0.86	0.89	0.88	0.82	0.93	1.19	0.79	0.64	0.66	0.69

Table 10. Mean bone-specific skeletal ages for the 31 individual hand-wrist bones of boys and girls, by geographic region and chronological age at last birthday, with selected standard errors: United States, 1963-65—Con.

Standard of reference, sex, and chronological age at last birthday	Trapezium				Trapezoid				Metacarpal I				Metacarpal II			
	North-west	Mid-west	South	West	North-east	Mid-west	South	West	North-east	Mid-west	South	West	North-east	Mid-west	South	West
Male standard																
Boys	Mean skeletal age in months															
6 years	77.7	76.8	75.7	77.2	81.2	81.6	79.0	80.4	72.9	71.0	72.0	71.5	75.8	74.9	75.4	74.2
7 years	84.1	86.0	82.2	80.9	88.8	90.6	86.2	86.0	84.9	85.2	82.4	82.4	88.4	88.2	84.4	84.6
8 years	92.9	91.6	94.1	91.6	97.1	95.9	98.1	97.0	95.3	94.6	95.0	92.6	97.1	95.3	96.8	94.2
9 years	101.8	102.6	102.6	100.0	106.2	107.1	106.6	104.7	104.0	105.0	104.7	103.1	106.4	106.6	105.6	102.6
10 years	110.6	110.4	110.1	108.7	114.1	113.3	112.9	112.2	112.4	113.1	112.4	109.5	113.0	113.0	113.6	111.0
11 years	125.0	120.3	121.4	120.0	126.3	122.1	121.7	122.7	126.0	121.8	122.6	122.3	125.6	121.1	122.2	122.6
Girls																
6 years	90.4	92.3	86.6	87.7	90.9	93.5	89.1	89.3	91.1	93.6	89.7	88.2	90.9	92.6	88.4	87.0
7 years	101.1	100.4	96.8	99.4	103.1	103.3	100.4	101.0	102.4	102.2	101.2	100.9	103.2	102.2	100.8	100.4
8 years	109.6	110.1	107.9	108.8	111.0	111.7	108.4	110.0	111.4	112.4	110.1	109.7	112.0	111.7	110.0	109.2
9 years	122.9	118.6	118.7	116.0	123.3	120.4	119.7	116.6	126.8	122.2	121.2	118.9	127.3	121.2	120.2	117.8
10 years	133.0	134.0	133.1	132.7	133.1	135.1	132.3	132.5	134.7	138.8	137.1	136.8	134.5	137.4	136.3	135.3
11 years	151.4	151.1	151.3	153.9	150.4	150.4	150.6	152.2	156.2	154.3	154.8	156.5	155.8	152.5	153.3	155.9
Female equivalent																
Girls																
6 years	83.2	84.1	79.8	81.7	77.9	81.5	76.1	76.3	76.1	78.6	74.7	73.2	75.9	77.6	73.4	72.0
7 years	88.1	87.4	85.6	86.7	90.6	90.3	88.4	89.0	87.4	87.2	86.2	85.9	88.3	87.2	85.9	85.7
8 years	95.6	96.0	93.9	94.8	96.0	96.6	94.4	95.5	97.4	98.4	96.6	96.4	97.0	96.7	95.0	94.6
9 years	106.9	103.6	103.7	101.0	107.6	105.4	104.7	101.6	109.9	107.1	106.2	103.9	110.3	106.2	105.2	102.8
10 years	114.0	114.5	114.0	113.8	114.1	115.6	113.6	113.8	115.4	117.8	116.6	116.4	115.2	116.7	116.2	115.6
11 years	125.2	125.0	125.2	126.9	124.7	124.7	124.8	126.2	128.6	127.6	127.9	128.8	128.4	126.5	127.2	128.4
Male standard																
Boys	Standard error of the mean															
6 years	1.11	1.59	1.02	1.28	0.81	1.64	0.66	1.32	0.90	1.41	0.72	1.80	1.14	1.88	0.88	1.49
11 years	0.75	1.06	0.55	2.60	0.80	0.90	0.48	2.01	0.93	0.86	0.53	2.19	0.93	0.75	0.78	1.59
Girls																
6 years	1.43	0.92	1.14	1.34	0.83	0.75	0.77	1.19	0.88	0.95	1.53	0.89	0.50	0.95	1.35	1.16
11 years	1.90	1.14	0.69	2.21	2.29	1.50	0.83	1.87	2.43	1.39	0.58	2.19	2.32	1.22	0.78	2.08
Actual values	Mean skeletal age in months															
Boys: 6-11 years	100.9	101.0	99.5	98.6	103.9	104.0	102.2	102.1	98.9	99.0	97.0	96.6	100.7	100.3	98.6	97.9
Girls: 6-11 years	116.0	117.8	116.5	115.5	116.3	119.1	117.4	116.0	118.1	120.8	119.7	117.3	118.5	119.8	118.9	116.4
Expected values																
Boys: 6-11 years	99.8	100.7	99.4	100.0	102.9	103.7	102.6	103.0	97.8	98.7	97.0	97.9	99.3	100.1	98.5	99.4
Girls: 6-11 years	114.8	117.1	117.8	116.1	115.5	117.9	118.5	117.0	117.2	119.9	120.4	118.5	116.7	119.3	119.7	117.8
	Standard error of the mean															
Boys: 6-11 years	0.49	0.68	0.68	1.08	0.49	0.53	0.73	1.29	0.71	0.34	0.56	1.44	0.69	0.40	0.58	1.21
Girls: 6-11 years	0.68	0.67	0.94	1.03	0.73	0.78	0.93	0.95	0.78	0.80	0.96	1.11	0.77	1.06	0.92	1.05

Table 10. Mean bone-specific skeletal ages for the 31 individual hand-wrist bones of boys and girls, by geographic region and chronological age at last birthday, with selected standard errors: United States, 1963-65—Con.

Standard of reference, sex, and chronological age at last birthday	Metacarpal III				Metacarpal IV				Metacarpal V				Pisiform			
	North-east	Mid-west	South	West	North-east	Mid-west	South	West	North-east	Mid-west	South	West	North-east	Mid-west	South	West
Male standard																
Boys	Mean skeletal age in months															
6 years	75.2	74.8	75.7	73.6	74.9	74.2	74.3	72.9	74.5	74.1	73.6	72.4	—	115.0	134.0	—
7 years	88.2	87.9	84.4	84.6	87.7	87.6	84.2	84.3	87.7	87.8	83.3	84.2	113.0	110.4	114.4	113.1
8 years	96.9	95.1	96.8	94.2	96.7	94.8	96.8	93.7	96.6	95.2	96.4	93.8	116.0	116.0	114.4	114.6
9 years	106.0	106.9	105.4	102.1	105.8	106.6	105.2	101.6	105.4	106.8	104.9	101.7	118.1	117.9	116.9	116.3
10 years	112.5	112.7	113.3	111.0	112.7	112.6	112.7	110.5	112.5	112.9	112.8	110.6	118.9	120.4	119.3	117.0
11 years	126.0	121.4	122.4	123.0	125.6	121.0	122.2	122.6	125.4	121.6	122.8	122.6	127.6	127.2	125.1	127.1
Girls																
6 years	90.7	93.0	88.1	87.2	90.4	92.2	87.9	86.7	90.4	92.5	87.2	86.4	119.7	117.2	112.0	114.6
7 years	103.2	102.3	100.5	100.2	103.2	101.4	100.4	99.6	102.8	101.2	99.7	99.5	116.5	117.4	114.9	119.3
8 years	111.8	111.9	110.0	109.1	111.6	111.4	109.8	108.4	111.2	111.7	109.6	108.7	119.4	121.5	119.0	120.2
9 years	127.1	121.5	120.4	118.0	127.0	121.5	120.2	118.0	127.5	122.4	120.9	118.0	128.3	125.5	126.0	124.5
10 years	135.2	138.5	136.7	136.1	134.8	138.3	136.7	136.0	136.1	140.0	138.0	137.4	138.0	140.7	137.7	137.0
11 years	156.6	153.7	153.8	156.9	156.5	153.8	154.1	156.8	157.4	155.3	155.1	158.4	152.5	152.7	153.6	156.8
Female equivalent																
Girls																
6 years	76.0	79.0	74.0	72.3	75.4	77.2	72.9	71.7	75.4	77.5	72.2	71.4	104.8	103.2	100.0	101.6
7 years	89.2	88.3	86.5	86.2	88.3	86.4	85.7	85.3	87.8	86.2	84.7	84.5	102.8	103.4	101.9	104.6
8 years	97.8	97.9	96.0	95.1	96.6	96.4	94.9	94.2	96.2	96.7	94.8	94.4	104.7	106.5	104.5	105.2
9 years	110.1	106.5	105.4	104.0	110.0	106.5	105.2	103.0	110.2	106.7	105.9	103.0	111.2	109.5	110.0	108.5
10 years	115.2	117.5	116.4	116.0	115.4	117.3	116.4	116.0	115.6	118.5	117.0	116.4	117.0	118.8	116.8	116.5
11 years	128.8	127.4	127.4	128.9	128.8	127.4	127.6	128.9	129.4	128.2	128.0	130.4	126.2	126.4	126.8	128.9
Male standard																
Boys	Standard error of the mean															
6 years	1.21	1.97	0.80	1.25	1.09	1.91	0.67	1.42	1.07	1.81	0.70	1.34	—	81.31	94.75	—
11 years	0.81	0.58	0.73	1.76	0.85	0.65	0.70	1.56	1.23	0.87	0.81	1.83	0.92	1.02	0.57	2.41
Girls																
6 years	0.48	0.86	1.40	1.20	0.44	0.87	1.28	1.19	0.49	1.04	1.24	1.24	5.25	1.93	25.08	36.35
11 years	2.17	1.21	0.76	2.24	2.07	1.23	0.76	2.46	2.02	1.09	0.82	2.40	2.10	1.41	0.68	2.19
Actual values	Mean skeletal age in months															
Boys: 6-11 years	100.5	100.3	98.6	97.8	100.2	99.9	98.1	97.4	100.0	100.2	97.8	97.3	122.6	123.0	121.7	122.5
Girls: 6-11 years	118.6	120.4	119.0	116.7	118.4	120.0	118.9	116.4	118.6	120.8	119.2	116.8	132.9	135.7	136.5	135.3
Expected values																
Boys: 6-11 years	99.2	100.0	98.4	99.3	98.8	99.6	98.0	98.9	98.8	99.6	98.0	98.8	122.2	122.3	122.5	123.1
Girls: 6-11 years	116.9	119.6	120.0	118.1	116.7	119.4	119.8	117.9	117.1	119.8	120.2	118.3	132.8	135.4	137.1	135.3
	Standard error of the mean															
Boys: 6-11 years	0.68	0.39	0.60	1.20	0.71	0.40	0.62	1.18	0.64	0.41	0.55	1.25	0.58	0.55	0.56	1.88
Girls: 6-11 years	0.78	1.05	0.95	1.02	0.77	1.04	0.92	1.04	0.80	1.12	0.99	1.13	1.27	1.25	1.01	1.38

Table 10. Mean bone-specific skeletal ages for the 31 individual hand-wrist bones of boys and girls, by geographic region and chronological age at last birthday, with selected standard errors: United States, 1963-65—Con.

Standard of reference, sex, and chronological age at last birthday	Adductor sesamoid				Flexor sesamoid				Proximal phalanx I				Proximal phalanx II			
	North-east	Mid-west	South	West	North-east	Mid-west	South	West	North-east	Mid-west	South	West	North-east	Mid-west	South	West
Male standard																
Boys	Mean skeletal age in months															
6 years	---	---	---	---	---	---	---	---	78.5	76.8	75.3	75.6	80.6	79.3	77.1	78.5
7 years	---	---	---	---	---	---	---	---	88.5	88.8	86.0	86.3	91.5	92.4	87.4	88.1
8 years	---	---	---	---	---	---	---	---	98.9	97.1	96.4	95.0	101.0	99.8	97.9	96.9
9 years	158.2	152.0	154.0	---	163.0	---	158.0	---	106.3	107.6	104.2	101.5	108.0	109.3	105.1	104.4
10 years	150.0	159.6	---	164.0	158.0	---	---	---	114.2	113.8	113.8	110.9	115.4	115.0	114.0	112.4
11 years	156.9	155.5	157.1	156.6	162.5	162.0	159.1	160.0	127.6	123.7	123.5	124.2	127.9	124.1	123.8	124.9
Girls																
6 years	152.0	---	---	---	---	---	---	---	91.8	92.5	89.0	86.8	94.4	96.1	90.7	89.1
7 years	150.0	---	---	160.0	---	---	---	160.0	103.4	101.0	99.4	99.1	106.1	103.9	101.6	101.8
8 years	159.1	154.9	148.4	153.7	171.0	158.0	---	158.0	113.8	115.4	110.6	110.7	115.1	115.9	112.1	111.8
9 years	158.8	154.4	157.8	155.4	162.3	160.3	161.8	160.0	132.4	126.1	125.4	121.7	131.5	125.5	124.5	121.9
10 years	158.9	157.9	158.9	158.5	163.4	162.6	161.9	161.6	140.6	143.6	141.5	141.2	140.3	143.4	141.1	141.4
11 years	162.7	162.7	163.7	162.5	166.6	165.6	166.5	164.9	161.2	159.7	159.9	161.7	161.5	159.8	159.5	161.3
Female equivalent																
Girls																
6 years	125.5	---	---	---	---	---	---	---	76.8	77.5	74.5	71.8	79.4	81.1	75.7	74.1
7 years	124.0	---	---	131.0	---	---	---	131.0	88.4	86.0	84.4	84.1	91.1	88.9	86.6	86.8
8 years	130.6	127.9	124.0	126.7	139.0	130.0	---	130.0	99.8	100.7	96.2	96.4	100.1	100.9	97.1	96.8
9 years	130.4	127.4	129.8	128.2	132.3	131.2	131.9	131.0	113.7	109.6	109.2	106.4	112.8	108.5	107.8	105.9
10 years	130.4	129.9	130.4	130.2	133.2	132.6	131.9	131.8	118.8	120.6	119.2	119.1	118.6	120.7	119.1	119.4
11 years	132.7	132.7	133.4	132.5	134.8	134.3	134.8	133.9	131.2	130.4	130.4	131.7	131.2	130.4	130.2	131.2
Male standard																
Boys	Standard error of the mean															
6 years	---	---	---	---	---	---	---	---	1.31	1.05	0.96	1.17	1.04	1.51	0.83	1.27
11 years	0.58	1.79	2.64	1.36	2.19	*	*	*	0.90	0.84	1.07	2.66	0.97	1.04	0.97	2.40
Girls																
6 years	107.48	---	---	---	---	---	---	---	0.71	0.79	0.80	1.05	0.76	0.80	0.93	1.19
11 years	0.55	0.45	0.83	0.72	1.40	0.82	1.06	0.93	2.31	1.40	1.12	2.39	1.81	1.02	0.95	2.57
Actual values	Mean skeletal age in months															
Boys: 6-11 years	156.6	156.0	156.8	156.8	162.0	162.0	158.9	160.0	102.0	101.7	98.7	98.7	103.7	103.7	99.8	100.6
Girls: 6-11 years	160.8	160.0	161.3	160.4	165.3	164.0	164.6	163.8	121.3	123.2	121.8	119.0	122.5	124.2	122.3	120.0
Expected values																
Boys: 6-11 years	156.5	156.8	156.4	156.6	160.5	161.0	160.7	161.0	100.2	101.0	99.5	100.3	101.9	102.7	101.2	102.0
Girls: 6-11 years	160.4	160.6	160.7	160.7	164.4	164.2	164.3	164.7	119.4	122.3	122.8	120.8	120.5	123.2	123.7	121.8
	Standard error of the mean															
Boys: 6-11 years	0.79	1.16	2.24	1.34	1.90	62.82	79.44	61.99	0.73	0.34	0.71	1.54	0.71	0.37	0.57	1.47
Girls: 6-11 years	0.52	0.43	0.57	0.46	0.84	0.60	0.90	1.01	0.91	0.99	0.89	1.39	0.87	0.93	0.95	1.29

Table 10. Mean bone-specific skeletal ages for the 31 individual hand-wrist bones of boys and girls, by geographic region and chronological age at last birthday, with selected standard errors: United States, 1963-65—Con.

Standard of reference, sex, and chronological age at last birthday	Proximal phalanx III				Proximal phalanx IV				Proximal phalanx V				Middle phalanx II			
	North-east	Mid-west	South	West	North-east	Mid-west	South	West	North-east	Mid-west	South	West	North-east	Mid-west	South	West
Male standard																
	Mean skeletal age in months															
Boys																
6 years	79.9	78.7	76.4	77.8	79.0	77.8	75.7	76.8	79.6	78.4	76.2	77.4	82.9	80.3	79.3	81.1
7 years	90.6	91.9	86.4	87.5	90.4	91.8	86.2	87.3	90.8	92.2	87.1	87.9	92.5	93.6	88.6	90.3
8 years	100.6	99.6	97.5	96.5	100.6	99.7	97.6	96.3	101.2	100.3	98.5	96.8	102.3	101.1	99.8	98.4
9 years	107.8	109.5	104.8	103.7	107.7	109.4	105.1	104.0	107.8	109.2	105.9	104.2	109.4	109.7	107.1	106.4
10 years	115.5	115.2	114.1	112.4	116.1	115.9	114.9	113.0	116.2	115.9	114.8	112.8	116.9	115.1	116.5	113.8
11 years	127.8	124.1	123.7	125.1	128.7	125.0	124.1	125.2	129.0	124.9	124.8	125.2	129.8	125.7	125.1	126.6
Girls																
6 years	94.1	95.9	90.0	88.2	93.8	95.4	89.9	88.2	94.3	95.8	90.2	88.8	95.8	96.8	91.9	90.6
7 years	105.6	103.5	101.3	101.0	105.6	103.9	101.0	101.3	106.0	103.9	101.1	101.6	106.2	103.6	102.1	101.9
8 years	114.8	115.9	111.6	111.9	115.1	116.6	111.6	112.0	115.4	116.8	112.5	112.2	116.3	115.7	112.5	112.5
9 years	131.4	125.3	124.5	121.9	131.8	125.9	124.7	122.1	132.3	126.2	124.7	122.5	131.7	126.1	125.0	122.6
10 years	140.4	144.2	141.1	141.3	140.4	144.0	141.2	141.6	140.8	143.7	141.8	141.9	141.2	143.2	140.7	141.4
11 years	161.6	160.1	159.5	161.7	161.1	160.4	160.0	161.9	161.6	160.4	160.0	162.0	160.5	159.1	160.0	161.5
Female equivalent																
Girls																
6 years	79.1	80.9	75.0	73.2	78.8	80.4	74.9	73.2	80.2	80.9	75.2	73.8	80.8	81.8	77.4	76.6
7 years	90.6	88.5	86.3	86.0	90.6	88.9	86.0	86.3	91.0	88.9	86.1	86.6	91.6	89.6	88.1	87.9
8 years	99.8	100.9	96.6	96.9	100.1	101.6	96.6	97.0	101.4	102.4	98.5	98.2	101.6	101.4	97.5	97.5
9 years	113.2	109.2	108.5	106.4	113.4	109.4	108.7	106.6	113.6	109.6	108.7	107.2	113.6	109.6	109.0	107.3
10 years	118.7	121.1	119.0	119.2	118.7	121.0	119.1	119.3	119.3	120.7	119.6	119.6	119.1	120.2	118.8	119.2
11 years	133.3	132.1	131.8	133.4	133.0	132.4	132.0	133.4	131.8	131.2	131.0	132.0	131.2	130.6	131.0	131.5
Male standard																
	Standard error of the mean															
Boys																
6 years	1.06	1.56	0.84	1.33	1.19	1.71	0.79	1.18	1.10	1.64	0.85	1.23	0.71	0.89	0.92	1.06
11 years	1.05	1.02	1.11	2.41	0.96	0.99	0.92	2.36	0.93	0.98	1.11	2.08	0.90	0.74	0.93	1.99
Girls																
6 years	0.87	0.87	0.86	1.12	0.95	0.89	0.96	1.06	0.83	0.90	0.99	1.03	1.11	0.77	1.12	0.80
11 years	1.86	1.05	0.91	2.60	1.91	1.22	0.92	2.50	1.65	1.18	1.01	2.33	2.18	1.26	0.93	2.43
Actual values	Mean skeletal age in months															
Boys: 6-11 years	103.4	103.6	99.4	100.2	103.4	103.7	99.4	100.2	103.7	104.0	100.1	100.5	105.3	104.6	101.6	102.5
Girls: 6-11 years	122.3	124.3	122.1	119.8	122.2	124.5	122.2	119.9	122.7	124.6	122.4	120.3	123.0	124.2	122.9	120.6
Expected values																
Boys: 6-11 years	101.6	102.4	100.9	101.7	101.6	102.4	100.9	101.7	102.0	102.8	101.2	102.1	103.4	104.2	102.7	103.6
Girls: 6-11 years	120.3	123.1	123.6	121.6	120.4	123.2	123.7	121.8	120.7	123.4	123.9	122.0	120.8	123.5	124.2	122.2
	Standard error of the mean															
Boys: 6-11 years	0.73	0.38	0.61	1.43	0.76	0.44	0.74	1.47	0.73	0.44	0.57	1.37	0.59	0.36	0.58	1.26
Girls: 6-11 years	0.88	1.02	0.95	1.37	0.91	0.93	0.90	1.42	0.92	1.00	0.82	1.34	1.03	0.87	0.81	0.93

Table 10. Mean bone-specific skeletal ages for the 31 individual hand-wrist bones of boys and girls, by geographic region and chronological age at last birthday, with selected standard errors: United States, 1963-65—Con.

Standard of reference, sex, and chronological age at last birthday	Middle phalanx III				Middle phalanx IV				Middle phalanx V				Distal phalanx I			
	North-east	Mid-west	South	West	North-east	Mid-west	South	West	North-east	Mid-west	South	West	North-east	Mid-west	South	West
Male standard																
Boys	Mean skeletal age in months															
6 years	81.1	78.7	77.9	79.2	81.2	79.4	78.2	79.8	80.8	78.6	76.9	79.6	76.2	74.2	73.3	73.4
7 years	91.3	91.9	87.4	88.4	91.7	93.0	88.1	89.5	91.2	92.2	87.6	89.6	89.0	89.0	85.1	85.5
8 years	101.2	99.9	98.6	97.3	101.6	100.5	99.2	97.9	101.2	101.1	98.8	98.4	101.0	99.9	98.8	96.9
9 years	108.7	109.1	106.5	105.6	108.4	108.5	106.9	105.8	108.2	109.2	107.3	105.7	108.9	108.9	107.2	105.5
10 years	116.5	114.8	115.7	113.3	116.0	114.2	115.2	113.0	116.3	114.4	115.7	113.2	116.5	115.4	114.8	112.6
11 years	129.1	125.6	125.0	126.4	128.2	124.6	123.8	125.2	128.7	125.2	124.7	125.9	128.9	125.0	124.6	125.2
Girls																
6 years	94.7	95.3	90.2	89.8	95.1	96.0	90.6	90.4	95.2	96.4	91.1	91.0	93.9	94.1	88.7	87.6
7 years	105.6	102.6	101.0	100.8	105.5	102.9	101.2	101.3	105.6	103.5	100.8	101.3	104.9	102.5	99.8	101.3
8 years	115.2	115.1	111.2	111.9	114.8	114.5	111.2	111.3	115.1	115.0	111.3	111.7	114.0	115.1	110.6	111.7
9 years	131.4	125.9	124.5	121.8	130.4	125.2	123.6	121.1	131.1	125.6	123.6	121.6	130.8	124.7	123.8	120.7
10 years	140.7	143.5	140.4	140.7	139.8	142.2	139.1	139.9	140.3	142.4	140.1	140.2	140.0	141.1	139.2	139.3
11 years	161.3	158.9	159.8	161.4	160.6	158.3	159.0	161.1	160.3	159.4	159.7	161.8	159.3	157.7	158.4	159.8
Female equivalent																
Girls																
6 years	79.7	80.3	76.2	75.8	80.1	81.0	76.6	76.4	78.3	80.1	72.2	72.0	77.9	78.1	72.7	71.8
7 years	91.3	88.6	87.0	86.8	91.2	88.9	87.2	87.3	91.3	89.5	85.8	86.4	89.9	87.5	84.8	86.3
8 years	101.1	101.0	96.2	96.9	100.7	100.2	96.2	96.3	100.1	100.0	96.3	96.7	99.0	100.1	95.6	96.7
9 years	113.5	109.4	108.5	106.8	113.1	109.1	107.8	106.1	112.6	108.6	107.3	106.3	112.8	107.8	107.4	105.7
10 years	118.8	120.5	118.7	118.8	118.4	119.6	118.0	118.4	118.3	119.7	118.1	118.2	118.0	119.0	117.6	117.6
11 years	131.4	130.4	130.9	131.5	131.2	130.2	130.5	131.4	130.8	130.5	130.6	131.8	130.6	129.7	130.2	130.9
Male standard																
Boys	Standard error of the mean															
6 years	0.45	0.87	0.90	1.29	0.71	0.83	0.91	1.26	0.94	0.64	1.02	1.09	0.97	1.11	1.15	1.52
11 years	0.93	0.76	0.83	2.28	0.90	0.81	0.83	2.28	0.74	0.82	1.11	2.18	0.61	0.82	0.91	2.29
Girls																
6 years	1.15	0.85	1.20	0.67	1.10	0.72	1.21	0.90	1.08	0.80	1.32	0.62	1.08	0.69	1.30	1.11
11 years	1.86	1.30	0.94	2.56	2.01	1.40	1.00	2.63	1.99	1.19	1.02	2.76	1.65	1.17	0.85	1.96
Actual values	Mean skeletal age in months															
Boys: 6-11 years	104.3	103.8	100.7	101.5	104.2	103.8	100.8	101.7	104.0	103.9	100.7	101.8	103.0	102.6	99.4	99.7
Girls: 6-11 years	122.5	123.7	122.0	119.9	122.1	123.4	121.6	119.7	122.2	123.8	122.0	120.1	121.1	122.4	120.8	118.5
Expected values																
Boys: 6-11 years	102.5	103.2	101.7	102.6	102.5	103.3	101.8	102.7	102.5	103.4	101.8	102.7	101.1	101.9	100.2	101.2
Girls: 6-11 years	120.2	122.9	123.4	121.5	119.9	122.6	123.1	121.2	120.1	122.9	123.5	121.6	118.8	121.6	122.3	120.2
	Standard error of the mean															
Boys: 6-11 years	0.62	0.39	0.70	1.31	0.63	0.38	0.65	1.43	0.63	0.48	0.66	1.40	0.84	0.41	0.76	1.54
Girls: 6-11 years	0.98	0.93	0.80	1.00	1.05	0.93	0.84	1.02	1.09	0.78	0.83	1.06	0.93	1.04	0.88	1.30

Table 10. Mean bone-specific skeletal ages for the 31 individual hand-wrist bones of boys and girls, by geographic region and chronological age at last birthday, with selected standard errors: United States, 1963-65—Con.

Standard of reference, sex, and chronological age at last birthday	Distal phalanx II				Distal phalanx III				Distal phalanx IV				Distal phalanx V			
	Northeast	Midwest	South	West	Northeast	Midwest	South	West	Northeast	Midwest	South	West	Northeast	Midwest	South	West
Male standard																
Boys	Mean skeletal age in months															
6 years	77.4	77.0	76.8	76.8	76.8	76.5	76.0	75.9	76.6	76.1	75.4	75.3	76.2	76.6	75.6	76.4
7 years	91.0	91.6	88.6	87.7	91.0	91.0	88.3	87.5	90.9	91.1	87.8	87.4	90.6	91.0	87.8	87.2
8 years	101.8	100.4	101.3	98.8	101.6	100.1	101.3	98.2	101.4	100.2	101.2	98.3	101.3	100.0	100.8	97.9
9 years	109.6	109.0	108.1	106.5	109.3	108.9	108.2	106.5	109.3	109.0	108.0	106.7	109.3	109.0	108.0	106.6
10 years	116.1	115.9	115.0	113.6	116.2	116.1	115.2	113.6	116.0	115.9	115.2	113.6	116.0	115.4	115.4	113.6
11 years	127.6	124.8	124.0	125.0	127.8	125.1	124.1	125.1	128.1	125.2	124.1	125.3	128.4	125.5	124.7	125.3
Girls																
6 years	95.6	96.3	90.9	91.4	95.1	95.8	90.5	91.0	95.2	95.6	90.6	90.4	94.8	95.6	90.4	91.0
7 years	106.5	104.4	102.2	102.3	106.4	104.2	101.9	101.8	106.3	104.3	101.9	101.8	106.5	103.8	101.6	101.8
8 years	113.7	114.4	111.6	111.4	113.7	114.2	111.3	111.2	113.7	114.4	111.2	111.1	113.4	114.4	110.9	111.0
9 years	129.6	123.2	123.3	119.7	129.7	123.2	123.4	119.5	129.8	123.1	123.5	119.7	129.8	123.1	123.2	119.6
10 years	138.2	139.3	137.6	137.2	139.2	139.6	138.4	137.2	138.6	139.8	138.9	137.6	139.3	140.1	138.9	137.9
11 years	158.1	155.2	157.3	158.8	158.1	155.7	157.4	158.9	158.4	156.4	157.8	159.3	158.7	157.0	158.2	159.4
Female equivalent																
Girls																
6 years	80.6	81.3	75.9	76.4	81.1	81.8	75.5	76.0	81.2	81.6	75.6	75.4	79.8	80.6	75.4	76.0
7 years	91.5	89.4	87.2	87.3	92.4	91.1	87.9	87.8	92.3	91.2	87.9	87.8	91.5	88.8	86.6	86.8
8 years	98.7	99.4	96.6	96.4	99.7	100.2	97.3	97.2	99.7	100.4	97.2	97.1	98.4	99.4	95.9	96.0
9 years	111.6	107.6	107.6	104.7	112.4	107.6	107.7	104.5	112.4	107.6	107.8	104.7	112.4	107.6	107.6	104.6
10 years	117.2	118.3	116.8	116.6	118.2	118.6	117.4	116.6	117.6	118.8	117.9	116.8	118.2	118.6	117.9	116.9
11 years	130.0	128.1	129.3	130.3	130.0	128.4	129.4	130.4	130.2	128.7	129.8	130.6	130.7	129.0	130.2	131.2
Male standard																
Boys	Standard error of the mean															
6 years	0.89	0.80	1.05	1.60	0.91	0.81	1.01	1.48	1.03	0.89	1.08	1.62	0.89	0.93	1.21	1.74
11 years	0.60	0.97	0.94	1.99	0.65	1.03	0.92	2.02	0.67	1.05	0.87	2.05	0.80	0.87	1.00	2.11
Girls																
6 years	1.25	0.82	1.24	0.85	1.25	0.90	1.32	0.86	1.33	1.00	1.34	0.75	1.25	0.96	1.24	0.93
11 years	1.72	1.48	0.83	2.12	1.79	1.36	0.82	2.05	1.78	1.37	0.95	2.01	1.77	1.28	0.80	2.01
Actual values	Mean skeletal age in months															
Boys: 6-11 years	103.6	103.6	101.2	101.2	103.4	103.4	101.0	101.0	103.4	103.4	100.8	100.9	103.3	103.4	100.9	101.0
Girls: 6-11 years	121.2	122.2	121.1	118.7	121.1	122.2	121.1	118.5	121.1	122.4	121.3	118.6	121.2	122.4	121.2	118.7
Expected values																
Boys: 6-11 years	102.3	103.1	101.5	102.4	102.1	102.9	101.3	102.3	102.0	102.9	101.2	102.2	102.1	102.9	101.2	102.2
Girls: 6-11 years	119.0	121.7	122.2	120.2	118.9	121.7	122.1	120.2	119.0	121.8	122.2	120.3	119.0	121.8	122.3	120.3
	Standard error of the mean															
Boys: 6-11 years	0.75	0.44	0.65	1.59	0.80	0.45	0.70	1.62	0.79	0.45	0.72	1.66	0.68	0.49	0.74	1.75
Girls: 6-11 years	1.06	0.90	0.83	1.07	1.05	0.96	0.88	1.09	1.05	0.85	0.90	1.10	1.11	0.93	0.91	1.13

Table 11. Mean bone-specific skeletal ages for selected hand-wrist bones of boys and girls, by annual family income and chronological age at last birthday, with selected standard errors: United States, 1963-65

Standard of reference, sex, and chronological age at last birthday	Triquetral						Metacarpal III					
	Less than $3,000	$3,000-$4,999	$5,000-$6,999	$7,000-$9,999	$10,000-$14,999	$15,000 or more	Less than $3,000	$3,000-$4,999	$5,000-$6,999	$7,000-$9,999	$10,000-$14,999	$15,000 or more
Male standard												
Boys	Mean skeletal age in months											
6 years	72.3	74.8	75.8	71.4	72.7	76.2	73.6	76.0	76.1	73.9	73.6	72.6
7 years	85.2	85.9	87.3	84.2	90.2	85.2	84.0	86.6	87.4	86.2	87.4	86.3
8 years	98.4	96.8	96.9	97.2	94.0	95.5	94.8	96.5	95.0	95.9	94.6	96.7
9 years	104.2	108.5	107.2	105.2	108.9	106.6	102.0	104.7	106.6	104.7	108.0	107.5
10 years	113.5	115.3	115.1	115.1	111.9	115.1	111.7	112.9	113.1	113.4	110.1	111.0
11 years	124.2	125.7	123.7	123.5	124.6	125.6	125.0	123.9	123.1	121.8	122.4	123.9
Girls												
6 years	91.2	89.8	87.1	90.3	90.5	88.8	90.2	90.1	88.4	90.8	87.8	92.2
7 years	102.6	100.9	101.5	102.8	101.0	107.4	102.2	100.6	101.0	102.0	101.1	108.5
8 years	108.6	112.1	111.3	112.3	109.8	111.5	107.5	111.5	111.4	112.5	109.0	113.1
9 years	120.1	119.3	119.9	123.9	122.1	124.2	119.4	120.5	121.3	123.7	125.3	122.3
10 years	134.1	133.6	133.8	133.9	132.5	136.6	138.2	135.9	135.8	136.5	135.1	140.5
11 years	150.4	148.9	151.2	150.0	149.0	153.5	154.1	155.2	155.4	156.1	153.6	157.7
Female equivalent												
Girls												
6 years	78.2	76.8	74.1	77.3	77.5	75.8	75.3	75.2	74.2	76.2	73.2	78.2
7 years	88.6	86.9	87.5	88.8	87.0	93.4	88.2	86.6	87.0	88.0	87.1	94.5
8 years	94.3	97.1	96.3	97.3	94.9	96.5	93.5	97.5	97.4	98.5	95.0	99.1
9 years	105.0	104.3	104.9	106.9	106.0	107.2	104.7	105.5	106.3	108.4	109.3	107.3
10 years	115.0	114.6	114.8	114.9	113.8	116.3	117.2	115.9	115.8	116.2	115.1	119.2
11 years	124.7	123.9	125.1	124.5	124.0	126.5	127.6	128.1	128.2	128.6	127.3	129.7
Male standard												
Boys	Standard error of the mean											
6 years	2.54	1.51	1.38	1.91	3.43	2.20	1.90	1.16	1.04	1.73	3.33	2.69
11 years	1.60	1.21	1.63	1.11	1.71	2.32	1.76	1.41	1.61	1.08	1.87	2.81
Girls												
6 years	1.00	1.47	1.53	1.60	1.79	3.73	1.48	1.97	1.73	0.91	1.82	4.26
11 years	1.87	1.52	0.99	1.12	2.04	3.53	1.60	1.51	1.07	1.26	2.06	4.10
Actual values	Mean skeletal age in months											
Boys: 6-11 years	99.2	100.4	100.2	100.4	101.0	100.8	97.7	99.2	99.4	100.1	99.8	99.7
Girls: 6-11 years	116.5	115.9	116.8	116.8	117.1	120.7	117.9	117.9	118.8	118.8	118.7	123.6
Expected values												
Boys: 6-11 years	99.8	99.5	99.5	101.2	100.9	100.3	98.7	98.6	98.7	100.2	100.0	99.6
Girls: 6-11 years	116.6	116.4	117.3	116.0	117.7	118.6	118.4	118.2	119.2	117.8	119.3	120.6
	Standard error of the mean											
Boys: 6-11 years	0.76	0.80	0.57	0.94	1.30	2.17	1.13	0.78	0.45	0.85	1.24	2.22
Girls: 6-11 years	0.88	0.71	0.94	0.58	1.23	1.97	1.07	0.89	1.11	0.70	1.40	1.90

Table 11. Mean bone-specific skeletal ages for selected hand-wrist bones of boys and girls, by annual family income and chronological age at last birthday, with selected standard errors: United States, 1963-65—Con.

Standard of reference, sex, and chronological age at last birthday	Metacarpal V						Proximal phalanx III					
	Less than $3,000	$3,000-$4,999	$5,000-$6,999	$7,000-$9,999	$10,000-$14,999	$15,000 or more	Less than $3,000	$3,000-$4,999	$5,000-$6,999	$7,000-$9,999	$10,000-$14,999	$15,000 or more
Male standard												
Boys	Mean skeletal age in months											
6 years	71.8	75.1	74.6	73.4	72.1	71.2	74.9	78.5	79.5	80.2	76.5	76.6
7 years	84.1	85.7	87.3	85.9	85.6	87.3	85.4	89.0	90.8	89.7	91.0	90.9
8 years	94.0	96.4	95.1	95.9	94.2	96.4	97.0	97.9	97.3	100.2	99.8	100.6
9 years	101.7	104.1	106.1	104.6	108.0	106.8	102.3	105.8	107.6	107.3	109.8	109.8
10 years	111.8	112.8	112.7	113.2	109.9	111.8	112.4	113.5	115.5	115.9	112.7	116.2
11 years	124.6	124.6	122.6	122.0	122.3	123.8	125.2	125.6	124.5	124.9	126.1	125.5
Girls												
6 years	89.8	89.0	87.8	90.3	87.8	91.6	92.0	89.0	91.0	95.3	91.4	94.6
7 years	101.7	99.9	99.8	101.6	99.8	107.3	103.1	101.9	101.2	105.0	102.1	108.8
8 years	107.3	111.4	110.8	112.1	108.3	112.6	109.5	114.9	113.4	116.5	112.4	112.7
9 years	119.9	120.4	121.9	124.9	125.5	122.7	122.6	122.3	125.8	129.8	129.3	129.2
10 years	139.4	137.5	137.0	137.5	136.8	141.6	141.5	141.3	141.5	142.0	142.3	144.8
11 years	155.2	156.7	156.7	157.3	155.4	159.2	159.9	160.5	160.5	161.5	160.2	163.5
Female equivalent												
Girls												
6 years	74.8	74.0	72.8	75.3	72.8	76.6	77.0	74.0	76.0	80.3	76.4	79.6
7 years	86.7	84.9	84.8	86.6	84.8	92.4	88.1	86.9	86.2	90.0	87.1	94.7
8 years	92.4	96.4	95.8	97.1	94.2	97.6	95.2	99.9	98.4	101.5	97.4	97.7
9 years	104.9	105.4	106.4	107.9	108.5	106.8	106.8	106.6	109.4	111.8	111.3	111.2
10 years	118.2	116.5	116.0	116.5	115.9	119.3	119.2	119.2	119.2	119.5	119.6	121.4
11 years	128.1	128.8	128.8	129.3	128.2	131.1	131.9	132.5	132.5	133.2	132.2	134.2
Male standard												
Boys	Standard error of the mean											
6 years	2.04	1.29	1.06	1.90	3.22	2.53	1.15	1.03	1.25	1.32	2.29	1.19
11 years	1.70	1.47	1.82	1.23	2.14	3.06	1.89	1.43	1.63	1.22	2.22	2.38
Girls												
6 years	1.40	2.08	1.75	1.07	1.87	4.34	0.90	1.93	1.52	1.01	2.27	4.77
11 years	1.74	1.44	1.06	1.18	1.75	3.84	1.65	1.52	0.88	1.69	1.77	3.74
Actual values	Mean skeletal age in months											
Boys: 6-11 years	97.1	98.9	98.9	99.9	99.2	99.5	98.8	100.9	101.8	103.7	103.0	103.2
Girls: 6-11 years	118.2	118.1	118.9	119.1	119.0	123.8	120.7	120.6	122.0	123.4	123.0	127.0
Expected values												
Boys: 6-11 years	98.3	98.2	98.3	99.8	99.6	99.2	101.2	101.1	101.1	102.6	102.4	102.0
Girls: 6-11 years	118.6	118.4	119.4	117.9	119.6	121.0	121.9	121.7	122.6	121.2	122.9	124.4
	Standard error of the mean											
Boys: 6-11 years	1.09	0.80	0.45	0.91	1.30	2.28	1.36	0.78	0.46	0.78	1.34	2.05
Girls: 6-11 years	1.19	0.97	1.11	0.71	1.44	2.07	1.19	1.02	1.14	0.79	1.55	2.07

Table 11. Mean bone-specific skeletal ages for selected hand-wrist bones of boys and girls, by annual family income and chronological age at last birthday, with selected standard errors: United States, 1963-65—Con.

Standard of reference, sex, and chronological age at last birthday	Proximal phalanx IV						Middle phalanx V					
	Less than $3,000	$3,000-$4,999	$5,000-$6,999	$7,000-$9,999	$10,000-$14,999	$15,000 or more	Less than $3,000	$3,000-$4,999	$5,000-$6,999	$7,000-$9,999	$10,000-$14,999	15,000 or more
Male standard												
Boys	Mean skeletal age in months											
6 years	74.3	77.3	78.8	78.9	75.9	75.9	75.9	80.2	80.4	81.0	75.3	75.8
7 years	85.2	89.0	90.4	89.6	91.0	90.7	87.5	90.0	91.8	90.6	90.9	90.5
8 years	96.9	98.0	97.5	100.0	100.0	100.4	97.8	100.1	99.5	101.4	101.0	99.2
9 years	102.4	106.1	107.6	107.4	109.6	110.2	103.7	107.6	109.0	108.0	109.6	111.0
10 years	112.8	114.1	116.0	116.9	113.5	116.5	113.6	114.0	115.8	116.7	113.6	114.0
11 years	125.4	126.1	125.4	125.3	126.7	127.2	125.9	126.6	126.1	125.5	126.5	127.6
Girls												
6 years	92.0	88.8	90.8	95.2	91.0	93.5	93.5	91.4	91.3	96.9	92.2	97.0
7 years	103.2	102.1	101.7	104.9	102.0	109.4	102.1	102.1	102.5	104.8	100.3	109.3
8 years	108.9	115.6	113.3	117.1	113.2	112.6	109.0	114.1	112.8	116.0	113.4	113.8
9 years	122.9	122.9	126.0	129.9	129.8	129.8	121.3	121.6	124.7	131.3	129.7	128.4
10 years	141.5	141.3	141.9	142.0	142.2	144.9	141.0	139.4	140.1	141.1	140.4	146.6
11 years	160.3	160.6	160.8	161.6	159.9	164.1	160.2	159.3	160.3	161.2	158.6	165.2
Female equivalent												
Girls												
6 years	77.0	73.8	75.8	80.2	76.0	78.5	75.0	72.6	72.4	80.8	74.1	81.0
7 years	88.2	87.1	86.7	89.9	87.0	95.2	87.6	87.6	88.2	90.8	85.3	94.3
8 years	94.8	100.6	98.3	102.1	98.2	97.6	94.0	99.1	97.8	101.0	98.4	98.8
9 years	106.9	106.9	109.5	111.9	111.8	111.8	106.2	106.3	107.8	112.6	111.7	110.7
10 years	119.2	119.2	119.4	119.5	119.6	121.4	119.0	117.4	118.1	119.0	118.4	122.3
11 years	132.3	132.6	132.8	133.3	131.9	134.4	130.7	130.4	130.8	131.2	130.2	134.2
Male standard												
Boys	Standard error of the mean											
6 years	1.29	1.12	1.31	1.45	2.44	1.25	1.46	1.40	1.24	1.39	2.48	1.65
11 years	1.78	1.44	1.66	1.24	2.11	2.15	1.36	1.62	1.48	1.02	2.22	3.03
Girls												
6 years	0.99	1.96	1.63	1.08	2.16	4.57	1.24	1.50	1.50	1.30	2.13	4.81
11 years	1.69	1.57	0.98	1.65	1.57	3.70	1.68	1.73	0.93	1.79	2.01	4.09
Actual values	Mean skeletal age in months											
Boys: 6-11 years	98.7	100.9	101.8	103.7	103.2	103.4	99.8	102.3	103.0	104.5	103.2	103.1
Girls: 6-11 years	120.8	120.8	122.2	123.5	123.0	127.1	120.5	120.3	121.8	123.6	122.6	128.0
Expected values												
Boys: 6-11 years	101.2	101.1	101.1	102.7	102.4	102.0	102.0	102.1	102.1	103.6	103.4	103.0
Girls: 6-11 years	122.1	121.8	122.7	121.3	122.9	124.5	121.9	121.6	122.5	121.0	122.8	124.0
	Standard error of the mean											
Boys: 6-11 years	1.38	0.84	0.46	0.81	1.44	2.10	1.21	0.77	0.52	0.87	1.57	2.12
Girls: 6-11 years	1.20	1.06	1.16	0.77	1.52	2.17	1.42	0.97	1.11	0.81	1.38	2.25

Table 12. Selected percentiles in the distribution of the individual child's range in bone-specific skeletal ages for the radio-opaque (not adult) bones in the hand-wrist for white and Negro boys and girls, by chronological age at last birthday: United States, 1963-65

Standard of reference, sex, and chronological age at last birthday	White			Negro		
	Percentile points					
	75	50	25	75	50	25
Male standard						
Boys	Bone-specific skeletal age range in months					
6 years	36.7	29.2	22.7	40.5	28.8	22.4
7 years	36.1	28.4	20.8	35.9	26.9	19.2
8 years	34.2	26.4	19.0	35.4	25.8	16.8
9 years	29.9	22.6	15.1	36.7	25.1	14.2
10 years	26.4	20.1	14.2	28.5	21.9	14.3
11 years	26.4	18.7	14.2	27.2	20.8	14.7
Girls						
6 years	34.3	27.1	20.6	36.4	28.1	19.9
7 years	31.4	23.4	15.1	32.5	24.9	17.7
8 years	28.9	21.5	14.5	28.7	22.0	14.9
9 years	30.5	22.3	15.4	27.8	22.1	14.5
10 years	32.2	24.3	17.3	30.9	24.7	20.2
11 years	33.9	24.3	17.0	32.3	24.4	17.9

Table 13. Selected percentiles in the distribution of the individual child's range in bone-specific skeletal ages for the radio-opaque (not adult) bones in the hand-wrist for boys and girls, by geographic region and chronological age at last birthday: United States, 1963-65

Standard of reference, sex, and chronological age at last birthday	Northeast			Midwest			South			West		
	Percentile points											
	75	50	25	75	50	25	75	50	25	75	50	25
Male standard												
Boys	Bone-specific skeletal age range in months											
6 years	36.7	29.2	22.1	37.4	30.2	22.1	36.5	27.4	22.5	37.0	31.0	24.3
7 years	35.6	28.3	22.0	36.3	28.3	20.3	36.7	28.3	20.4	37.4	28.3	20.8
8 years	36.6	24.1	17.6	33.5	26.6	20.3	34.9	26.2	19.6	34.3	27.6	20.2
9 years	27.7	20.5	14.8	30.3	23.8	16.1	29.6	20.3	14.2	30.6	24.1	14.8
10 years	25.5	20.3	14.3	26.1	20.3	14.3	29.3	22.4	14.9	24.8	17.9	13.3
11 years	27.1	18.6	13.6	25.5	20.1	14.5	24.5	18.7	14.4	28.3	19.4	13.3
Girls												
6 years	34.4	27.8	20.1	32.5	26.9	22.4	35.7	29.3	21.8	34.4	26.4	19.9
7 years	29.7	21.8	14.7	31.4	23.6	15.4	34.7	26.6	18.5	30.2	22.3	14.2
8 years	30.1	20.9	14.3	31.3	22.6	16.2	27.7	20.8	13.6	28.6	22.2	15.4
9 years	30.2	22.2	16.2	33.2	23.9	15.4	30.1	22.7	16.2	27.0	18.5	13.9
10 years	29.4	23.1	16.6	33.5	25.8	18.6	30.4	24.9	18.8	32.6	22.6	16.0
11 years	28.9	22.6	17.2	35.8	24.9	18.6	33.1	24.7	15.7	32.8	24.2	17.4

Table 14. Selected percentiles in the distribution of the individual child's range in bone-specific skeletal ages for the radio-opaque (not adult) bones in the hand-wrist for boys and girls, by annual family income and chronological age at last birthday: United States, 1963-65

Standard of reference, sex, and chronological age at last birthday	Less than $5,000			$5,000-$9,999			$10,000 or more		
	Percentile points								
	75	50	25	75	50	25	75	50	25
Male standard									
Boys	Bone-specific skeletal age range in months								
6 years	36.4	29.5	23.4	38.9	30.2	22.8	36.9	28.7	22.8
7 years	35.4	26.6	20.1	36.8	29.9	21.9	41.0	30.3	22.5
8 years	34.3	26.4	19.2	36.6	27.9	20.5	34.4	26.4	20.1
9 years	30.5	23.1	14.8	30.9	23.0	16.4	30.1	23.0	14.9
10 years	27.4	20.6	14.1	30.2	22.5	16.0	25.7	20.1	14.5
11 years	26.0	19.8	14.4	29.0	21.5	15.1	26.6	18.5	13.6
Girls									
6 years	34.8	27.1	20.4	34.5	27.6	20.7	33.0	27.4	23.2
7 years	32.8	24.0	16.7	31.7	24.2	16.7	31.1	18.2	12.2
8 years	25.9	19.8	12.1	28.9	20.8	14.4	28.1	20.7	14.5
9 years	28.0	21.8	15.1	32.3	23.1	15.2	29.9	21.3	16.2
10 years	30.2	23.7	17.9	32.1	24.5	16.7	34.5	24.9	18.3
11 years	32.7	24.9	18.0	34.1	23.2	17.5	32.2	24.5	16.5

Table 15. Median (chronological) age of onset of ossification in selected hand-wrist bones for boys and girls 6-11 years: United States, 1963-65

Race, region, and annual family income	Boys				Girls	
	Ulna	Trapezium	Trapezoid	Pisiform	Pisiform	Adductor
Race	Chronological age in years					
White	7.2	6.4	6.4	11.2	8.7	10.6
Negro	7.0	4.9	6.1	11.3	8.9	10.7
Region						
Northeast	7.0	6.3	6.2	11.0	8.5	10.7
Midwest	7.0	6.5	6.5	11.5	8.8	10.7
South	7.3	6.2	6.4	11.0	8.8	10.6
West	7.3	6.0	6.0	11.4	8.9	10.7
Annual family income						
Less than $5,000	7.2	6.2	6.5	11.2	8.9	10.6
$5,000-$9,999	7.1	6.3	6.4	11.3	8.8	10.9
$10,000 or more	7.0	6.3	6.0	11.3	8.7	10.5

APPENDIX I
STATISTICAL NOTES

Survey Design

The sample design for the second cycle of the Health Examination Survey, similar to the one used for the first cycle, was that of a multistage stratified probability sample of loose clusters of persons in land-based segments. Successive elements dealt with in the process of sampling are primary sampling unit (PSU), census enumeration district (ED), segment, household, eligible child (EC), and finally, the sample child (SC).

At the first stage, the nearly 2,000 PSU's into which the United States (including Hawaii and Alaska) had been divided and then grouped into 357 strata for use in the Current Population Survey and the Health Interview Survey were further grouped into 40 superstrata for use in Cycle II of the HES. The average size of each Cycle II stratum was 4.5 million persons, and all fell between the limits of 3.5 and 5.5 million. Grouping into 40 strata was done in a way that maximized homogeneity of the PSU's included in each stratum, particularly with regard to degree of urbanization, geographic proximity, and degree of industrialization. The 40 strata were classified into four broad geographic regions (each with 10 strata) of approximately equal population and cross-classified into four broad population density groups (each having 10 strata). Each of the 16 cells contained either two or three strata. A single stratum might include only one PSU (or only part of a PSU, as, for example, New York City, which represented two strata) or several score PSU's.

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

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

Generally, 20 ED's were selected within a particular PSU. The probability of selection of a particular ED was proportional to its population in the age group 5-9 years in the 1960 census which by 1963 roughly approximated the population in the target age group for Cycle II. A similar method was used for selecting one segment (clusters of households) in each ED. Each of the resultant 20 segments was either a bounded area or a cluster of households (or addresses). All the children in the age range 6-11 years normally resident at each household or address were considered EC's. Operational considerations made it necessary to reduce the number of prospective examinees at any one location to a maximum of 200. The EC's to be excluded for this reason from the SC group were determined by systematic subsampling.

The total sample thus selected for the examination included 7,417 children (SC's) from 25 different States in the 6-11 year age group with approximately 1,000 in each of the single years of age.

Reliability

Measurement and assessment processes employed in the Survey were highly standardized and closely controlled. Of course, this does not mean that the correspondence between the real world and the Survey results is exact. Data from the Survey are imperfect for three major reasons: (1) results are subject to sampling error, (2) the actual conduct of a survey never agrees perfectly with the design, and (3) the measurement or assessment processes themselves are inexact even though standardized and controlled.

The first report on Cycle II[5] describes in detail the faithfulness with which the sampling design was carried out. It notes that 7,119 out of the 7,417 sample children were examined. This is a response rate of 96 percent. The examined children were a highly representative sample of this age in the noninstitutional population of the United States. The response levels for the various demographic subgroups, including those for age, sex, race, region, population density, parent's educational level, and family income, show no marked differentials. Hence, it appears unlikely that nonresponse could have biased the findings markedly in these respects. Further description of the sample design and estimation procedures are contained in a subsequent report.[168]

The general measures used to control the quality of data from this survey have been cited previously,[5,169] those relating specifically to the assessment of skeletal age are outlined in an earlier section of this report.

Data recorded for each sample child are inflated in the estimation process to characterize the larger universe of which the sample child is representative. The weights used in this inflation process are a product of the reciprocal of the probability of selecting the child, an adjustment for nonresponse cases, and a poststratified ratio adjustment, which increases precision by bringing survey results into closer alignment with known United States population figures by color and sex within single years of age 6 through 11.

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

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

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

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

In addition to children not examined at all, there were 157 for whom there was no radiograph or else the radiograph could not be assessed. The age and sex distribution for these 157 children as well as for the 6,962 for whom assessments were made is shown in table I. No attempt was made to estimate the skeletal age for this group of children without usable radiographs. Hence it is assumed that the distribution of their skeletal ages is similar to that for the remaining 6,962. In other words, they were treated as if they were nonresponders.

Among the usable radiographs of the 6,962 children, there were a few in which the film quality was not good enough to permit assess-

Table I. Number of examined children whose hand-wrist radiographs were assessed and of those whose radiographs were not assessed for skeletal age, by chronological age in years and sex: Health Examination Survey, 1963-65

Chronological age at last birthday	Radiographs assessed		Radiographs not assessed	
	Boys	Girls	Boys	Girls
	Number of children			
Total	3,545	3,417	87	70
6 years	554	521	21	15
7 years	615	602	17	7
8 years	602	600	16	13
9 years	582	562	21	19
10 years	570	576	6	8
11 years	622	556	6	8

ment of all ossifying or ossified bones. In general, these would have been bones that had become radio-opaque recently. The number of children for whom bone-specific skeletal ages were assessed and in which the bone was considered as ossifying or completely ossified (adult) is shown in table II.

Sampling and Measurement Error

In the present report, reference has been made to efforts to minimize bias and variability of measurement techniques.

The probability design of the Survey makes possible the calculation of sampling errors. The sampling error is used here to determine how imprecise the Survey test results may be because they come from a sample rather than from the measurements of all elements in the universe.

The estimation of sampling errors for a study of the type of the Health Examination Survey is difficult for at least three reasons: (1) measurement error and "pure" sampling error are confounded in the data—it is not easy to find a procedure that will either completely include both or treat one or the other separately, (2) the Survey design and estimation procedure are complex and accordingly require computationally involved techniques for the calculation of variances, and (3) thousands of statistics came from the Survey, many for subclasses of the population for which there are few cases. Estimates of sampling error are obtained from the sample data and are themselves subject to sampling error, which may be large when the number of cases in a cell is small or occasionally even when the number of cases is substantial.

Table II. Number of examined children for whom skeletal age assessments were made on each of the 31 hand-wrist bones, by type of bone and sex: Health Examination Survey, 1963-65

Hand-wrist bone	Radio-opaque[1] not adult		Adult	
	Boys	Girls	Boys	Girls
	Number of children			
Radius	3,540	3,417	0	0
Ulna	2,806	3,201	0	0
Capitate	3,540	3,375	0	26
Hamate	3,540	3,387	0	24
Triquetral	3,518	3,322	0	62
Lunate	3,448	3,363	0	25
Scaphoid	3,151	3,352	0	19
Trapezium	3,046	3,311	0	32
Trapezoid	3,180	3,338	0	32
Metacarpal I	3,538	3,409	0	6
Metacarpal II	3,541	3,411	0	3
Metacarpal III	3,542	3,411	0	3
Metacarpal IV	3,542	3,411	0	3
Metacarpal V	3,542	3,410	0	3
Proximal phalanx I	3,539	3,407	0	6
Proximal phalanx II	3,542	3,410	0	4
Proximal phalanx III	3,543	3,410	0	4
Proximal phalanx IV	3,543	3,406	0	7
Proximal phalanx V	3,543	3,406	0	8
Middle phalanx II	3,538	3,405	0	4
Middle phalanx III	3,536	3,411	0	2
Middle phalanx IV	3,538	3,410	0	2
Middle phalanx V	3,526	3,388	0	6
Distal phalanx I	3,533	3,371	0	18
Distal phalanx II	3,532	3,380	0	19
Distal phalanx III	3,531	3,383	0	20
Distal phalanx IV	3,532	3,387	0	18
Distal phalanx V	3,532	3,382	0	17
Pisiform	746	1,789	0	56
Adductor sesamoid	88	837	0	9
Flexor sesamoid	21	321	0	6

[1] In long and short bones, "radio-opaque" refers to the epiphyses.

Estimates of approximate sampling variability for selected statistics used in this report are presented in the detailed tables. These estimates have been prepared by a replication technique that yields overall variability through observation of variability among random subsamples of the total sample. The method reflects both "pure" sampling variance and a part of the measurement variance.

In accordance with usual practice, the interval estimate for any statistic may be considered the range within 1 standard error of the tabulated statistic, with 68-percent confidence, or the range within 2 standard errors of the tabulated statistic, with 95-percent confidence. The latter is used as the level of significance in this report.

An approximation of the standard error of a difference $d = x - y$ of two statistics x and y is given by the formula $S_d = (S_x^2 + S_y^2)^{1/2}$, where S_x and S_y are the sampling errors, respectively, of x and y.

Expected Values

In the detailed tables both the actual and expected mean skeletal ages are shown for children in the various demographic groups. The expected mean values are obtained by assuming that the national age-specific mean values apply within the appropriate age subgroup for which the value is derived.

For example, if in an area (e.g., the Northeast) estimates from the Health Examination Survey show n_i boys in the i^{th} age group ($i = 1,2,\ldots,6$; $\Sigma n_i = n$) and the estimates of mean skeletal age for all U.S. boys in the i^{th} age group to be $\overline{X}_i$, then the expected mean skeletal age for boys in that area is:

$$\frac{1}{n} \sum_i n_i \overline{X}_i$$

The specific area may have higher values for younger boys and lower values for older boys than in the other areas. In that case the expected average may obliterate one or both of these differentials. These types of limitations need to be kept in mind in interpreting these data. The standard error of the difference between an actual and an expected mean value may be approximated by the standard error of the actual value.

Small Categories

In some tables, magnitudes are shown for cells for which the sample size is so small that the sampling error may be several times as great as the statistic itself. Obviously in such instances the statistic has no meaning in itself except to indicate that the true quantity is small. Such numbers, if shown, have been included in the belief that they may help to convey an impression of the overall story of the table.

APPENDIX II
DEMOGRAPHIC AND SOCIOECONOMIC TERMS

Age.—The age recorded for each child was the age at last birthday on the date of examination. The age criterion for inclusion in the sample used in this survey was defined in terms of age at time of interview. Since the examination usually took place 2-4 weeks after the interview, some of those who were 11 years old at the time of interview became 12 years old by the time of examination. There were 72 such cases. In the adjustment and weighting procedures used to produce national estimates, these 72 were included in the 11-year-old group.

Race.—Race was recorded as "white," "Negro," or "other." "Other" included American Indians, Chinese, Japanese, and all races other than white or Negro. Mexican persons were included with "white" unless definitely known to be American Indian or of other nonwhite race. Negroes and persons of mixed Negro and other parentage were recorded as "Negro."

Geographic region.—For purposes of stratification, the United States was divided into four broad geographic regions of approximately equal population. These regions, which correspond closely to those used by the Bureau of the Census, were as follows:

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

Urban-rural.—The definition of urban-rural areas was the same as that used in the 1960 Census. According to this definition, the urban population was comprised of all persons living in (1) places of 2,500 inhabitants or more incorporated as cities, boroughs, villages, and towns (except towns in New England, New York, and Wisconsin); (2) the densely settled urban fringe, whether incorporated or unincorporated of urbanized areas; (3) towns in New England and townships in New Jersey and Pennsylvania that contained no incorporated municipalities as subdivisions and had either 2,500 inhabitants or more, or a population of 2,500 to 25,000 and a density of 1,500 persons or more per square mile; (4) counties in States other than the New England States, New Jersey, and Pennsylvania that had no incorporated municipalities within their boundaries and had a density of 1,500 persons or more per square mile; and (5) unincorporated places of 2,500 inhabitants or more not included in any urban fringe. The remaining population was classified as rural.

Urban areas are further classified by population size for places within urbanized areas and other urban places outside urbanized areas.

Grade in school.—The grade that the child attended at the time of the interview was used here and later verified against school records. The grade of those children on summer vacation was considered to be the grade that they would enter when school resumed.

Education of parent or guardian.—This was recorded as the highest grade completed in school. The only grades counted were those attended in a regular school where persons were given formal education in graded public or private schools, whether day or night school, and whether attendance was full or part time. A "regular" school is one that advances a person toward an elementary or high school diploma, or a college, university, or professional school degree. Education in vocational, trade, or business schools outside the regular school system was not counted in determining the highest grade of school completed.

Family income.—The income recorded was the total income of the past 12 months received by the head of the household and all other household members related to the head by blood, marriage, or adoption. This income was the gross cash income (excluding pay in kind) except in the case of a family with their own farm or business, in which case net income was recorded.

Parent.—A parent was the natural parent or, in the case of adoption, the legal parent of the child.

Guardian.—A guardian was responsible for the care and supervision of the child. He or she did not have to be the legal guardian to be considered the guardian for this survey. A guardianship could only exist when the parent(s) of the child did not reside within the sample household.

Head of household.—Only one person in each household was designated as the "head." He or she was the person who was regarded as the "head" by the members of the household. In most cases, the head was the chief breadwinner of the family, although this was not always true. In some cases, the head was the parent of the chief earner or the only adult member of the household.

APPENDIX III
RELIABILITY OF ASSESSMENTS

To provide the basis for determining the level of reliability of the bone-specific skeletal age assessments made by the six medical students at Case Western Reserve University from hand-wrist radiographs of the 6- to 11-year-old children examined in the Health Examination Survey of 1963-65, a randomly selected sample of 1 in 24 films was reassessed by the same reader and approximately 1 in 24 independently randomly selected films was reassessed by another, as described previously. All six readers, before starting these final assessments, had been trained by Dr. Pyle in the Greulich-Pyle method using the HES Standard to the point that their ratings were in close agreement with hers. In all, 297 self-replicate assessments and 288 cross-replicate assessments were obtained. Thus, each reader made approximately the same number of self- and cross-replicate assessments.

All six readers maintained a high level of consistency in their own assessments throughout all 40 stands of examinations in the Survey. The mean difference in self-replicate assessments for all six readers combined was 0.8 month for all 31 bones and just slightly less—0.7 month—if the bones that are late to ossify (the pisiform, adductor sesamoid, and flexor sesamoid) are excluded. Considering data from all 31 bones, the mean difference per reader between his original and self-replicate assessment ranges from 0.0 to 1.4 months (combining data for the two sexes). For the 28 bones that ossify relatively early, the mean differences ranged from 0.0 to 1.5 months among the six readers (table III).

A consistently high level of agreement in bone-specific skeletal age assessments was also maintained among the 6 readers but the level was, as expected, somewhat lower than that for the individual readers with themselves. On all 31 hand-wrist bones, the mean cross-replicate differences between the original and the replicate assessment by another reader was 0.0 months. It ranged between +1.4 and +3.6 months for three of the readers and −1.2 to −3.3 for the other three readers. When only the 28 centers that ossify relatively early are considered, the overall mean difference was nearly identical to that for all 31 bones (table IV).

A further independent test of the validity and reliability of the skeletal age assessments in this study was made on a randomly selected group of 50 hand-wrist radiographs among the 11-year-old boys in the national study. These 50 films were reassessed independently by an assessor at Fels Research Institute who was proficient in the use of the Greulich-Pyle method but had not been trained by Dr. Pyle. The assessor at Fels Institute was not told the age or sex of the children nor did she have access to the previous skeletal age assessments. Her mean skeletal age (hand-wrist) for the 50 radiographs was 0.7 month lower than the original assessment for them in the national study. Her mean bone-specific skeletal ages ranged from 3.6 months greater on the scaphoid to 2.9 months less on the ulna than the original assessments (table V).

The aspects considered include consistency within observers (intraobserver differences), comparability between observers (interobserver differences), and differences resulting from vari-

Table III. Mean difference in cross- and self-replicate assessments of bone-specific skeletal ages from hand-wrist radiographs of examinees of chronological ages 6-11 years (at last birthday), by reader: Health Examination Survey, 1963-65

Assessor	Self-replicate				Cross-replicate				Type of replication	
	Range in mean differences		Average mean difference		Range in mean differences		Average mean difference			
	31 bones	28 bones[1]	31 bones	28 bones[1]	31 bones	28 bones[1]	31 bones	28 bones[1]	Cross	Self
	Months of skeletal age								Number of bones assessed	
Both sexes										
Assessor 1...	0.0-1.8	0.0-1.8	0.0	0.0	0.7-10.7	0.7-10.7	3.6	3.7	724	758
Assessor 2...	0.0-7.0	0.0-2.5	0.3	0.3	0.04-10.5	0.04-7.5	2.9	2.9	1,771	1,694
Assessor 3...	0.1-3.0	0.1-2.1	0.7	0.7	0.03-5.6	0.03-5.6	–2.2	–2.2	2,130	1,869
Assessor 4...	0.1-2.4	0.1-2.4	0.6	0.6	0.1-13.1	0.1-7.7	–1.2	–1.3	970	936
Assessor 5...	0.1-4.7	0.1-4.7	0.7	0.7	0.1-7.0	0.1-6.3	–3.3	–3.2	1,395	1,293
Assessor 6...	0.6-3.6	0.6-3.6	1.4	1.5	0.2-5.1	0.2-5.1	1.4	1.5	1,415	1,597
Boys										
Assessor 1...	0.1-1.8	0.1-1.8	0.2	0.2	0.6-10.7	0.6-10.7	3.8	3.9	360	384
Assessor 2...	0.0-7.0	0.0-2.5	0.3	0.1	0.03-7.5	0.03-7.5	2.8	2.6	932	869
Assessor 3...	0.1-3.0	0.1-2.1	1.3	0.7	0.3-5.5	0.3-5.5	–2.5	–2.5	1,063	889
Assessor 4...	0.0-2.1	0.0-2.1	0.4	0.8	0.1-6.7	0.1-6.7	–1.0	–1.4	461	477
Assessor 5...	0.1-4.7	0.1-4.7	1.0	0.9	0.1-6.5	0.1-6.3	–3.6	–3.0	502	710
Assessor 6...	0.1-3.5	0.1-3.5	1.6	1.2	0.7-5.1	0.7-5.1	1.7	2.0	863	612
Girls										
Assessor 1...	0.0-1.0	0.0-0.9	0.0	0.0	0.2-5.5	0.2-5.5	3.3	3.5	364	374
Assessor 2...	0.03-1.7	0.03-1.7	0.3	0.4	0.6-10.5	0.6-5.5	2.9	3.3	839	825
Assessor 3...	0.1-1.6	0.1-1.6	0.8	0.6	0.3-5.6	0.3-5.6	–2.0	–2.0	1,067	980
Assessor 4...	0.1-2.4	0.1-2.4	0.8	0.4	1.6-13.1	1.6-7.7	–1.4	–1.2	509	459
Assessor 5...	0.1-2.7	0.1-2.7	0.5	0.6	0.2-7.0	0.2-5.6	–3.9	–3.9	893	583
Assessor 6...	0.6-3.6	0.6-3.6	0.8	1.7	1.0-3.8	1.0-3.8	1.2	1.1	552	985

[1] Excluding the pisiform and adductor and flexor sesamoids.

ations in the way the Greulich-Pyle Atlas has been used. This review is restricted to reports based on samples of at least 10 radiographs and to the chronological age range 6-11 years.

While it is impossible to determine the true maturity level of the bones visualized in a radiograph, the reliability of assessments should be defined both within and between observers. As stated by Greulich and Pyle[6]:

> Though the ability to duplicate assessments with a good degree of consistency must be possessed by a competent assessor, it alone is not enough. It is even more important that the assessments be made correctly, that is, that they be made according to the method recommended by the particular radiographic atlas on which they purport to be based.

Unfortunately, the suggestion by Moore[170] that sets of duplicate radiographs that have been assessed by recognized experts be available to those who wish to measure their level of comparability has not been implemented.

Area Skeletal Ages

It is not easy to compare reported findings because workers have analyzed their data in different ways. For intraobserver differences, 95-percent confidence limits of 7.2 months[171] and mean differences ranging from 1.2 to 6.6

Table IV. Mean differences in cross- and self-replicate assessments of bone-specific skeletal ages from hand-wrist radiographs of examinees of chronological ages 6-11 years (at last birthday), by bone: Health Examination Survey, 1963-65

Hand-wrist bone	Self-replicate			Cross-replicate		
	Total	Boys	Girls	Total	Boys	Girls
	Months of skeletal age					
Radius	0.8	0.4	0.9	0.0	0.1	0.0
Ulna	0.3	0.2	0.3	0.0	0.0	0.1
Capitate	0.2	0.5	0.2	0.0	0.0	0.1
Hamate	0.4	0.3	0.5	0.1	0.0	0.2
Triquetral	1.2	1.6	0.6	0.0	0.0	0.1
Lunate	0.1	0.0	0.2	0.5	0.6	0.4
Scaphoid	0.2	0.2	0.2	0.1	0.0	0.2
Trapezium	0.3	0.2	0.3	0.3	0.5	0.2
Trapezoid	0.4	0.5	0.4	0.0	0.1	0.0
Metacarpal I	0.9	1.0	0.9	0.0	0.0	0.1
Metacarpal II	1.0	1.1	1.1	0.6	0.7	0.6
Metacarpal III	0.6	0.7	0.7	0.0	1.0	0.1
Metacarpal IV	0.7	0.8	0.7	0.0	0.0	0.1
Metacarpal V	0.7	0.9	0.6	0.0	0.0	0.1
Proximal phalanx I	0.8	0.5	1.2	0.0	0.0	0.1
Proximal phalanx II	0.3	0.2	0.4	0.0	0.0	0.1
Proximal phalanx III	0.4	0.3	0.6	0.0	0.0	0.1
Proximal phalanx IV	0.8	0.9	0.7	0.0	0.0	0.1
Proximal phalanx V	0.4	0.5	0.4	0.0	0.0	0.1
Middle phalanx II	0.6	0.8	0.5	0.0	0.0	0.1
Middle phalanx III	0.5	0.7	0.3	0.0	0.0	0.1
Middle phalanx IV	0.5	0.7	0.3	0.0	0.0	0.1
Middle phalanx V	0.9	1.0	0.8	0.0	0.1	0.0
Distal phalanx I	0.2	0.5	0.2	0.0	0.0	0.1
Distal phalanx II	0.4	0.5	0.3	0.0	0.1	0.0
Distal phalanx III	0.6	0.5	0.6	0.0	0.1	0.0
Distal phalanx IV	0.7	0.9	0.6	0.0	0.1	0.0
Distal phalanx V	0.5	0.7	0.4	0.0	0.0	0.1
Pisiform	0.3	0.4	0.2	0.0	0.1	0.0
Adductor sesamoid	0.5	0.2	0.4	0.0	0.0	0.0
Flexor sesamoid	0.4	0.3	0.6	3.6	-	3.6

months have been reported[8,172-175] in addition to variable errors of 1.4 to 4.2 months.[176,177] The median intraobserver differences range from zero to 4 months.[178-180] A report of zero median differences seems surprising at first but it is possible because Moed and his coworkers made overall assessments to the nearest atlas standard. The reliability of the HES data compare favorably with the preceding.

Todd's [18] claim that interobserver differences less than 6 months could be achieved readily appears justified. Reported mean interobserver differences range from 1.3 to 4.2 months.[8,181,182] In addition, a root mean square of 6.2 months and confidence limits of 7.4 months have been reported.[171,175] Reported incidences of particular interobserver differences indicate that the medians were less than 3 months for the study by Hansman and Maresh[183] and less than 6 months for the study by Moed et al.[178] The mean interobserver differences among readers in the national sur-

Table V. Mean difference on 50 radiographs of 11-year-old boys between original assessments at Case Western Reserve University and reassessment at Fels Research Laboratory: Health Examination Survey, 1963-65

Hand-wrist bone	Mean difference
	Skeletal age in months
Total	−0.7
Radius	−0.1
Ulna	−2.9
Capitate	−2.8
Hamate	−1.6
Triquetral	+0.9
Lunate	+1.0
Scaphoid	+3.6
Trapezium	+1.7
Trapezoid	+0.9
Metacarpal I	+1.4
Metacarpal II	+0.3
Metacarpal III	+0.5
Metacarpal IV	0.0
Metacarpal V	−0.3
Proximal p .lanx I	−1.3
Proximal phalanx II	−2.6
Proximal phalanx III	−1.2
Proximal phalanx IV	−1.5
Proximal phalanx V	−1.5
Middle phalanx II	+0.9
Middle phalanx III	−0.3
Middle phalanx IV	−1.7
Middle phalanx V	−0.7
Distal phalanx I	+1.2
Distal phalanx II	−1.6
Distal phalanx III	−1.9
Distal phalanx IV	−1.6
Distal phalanx V	−2.0
Pisiform	−2.6
Adductor sesamoid	−0.5
Flexor sesamoid	---

vey are toward the lower end of the sample values reported by others.

Bone-Specific Skeletal Ages

Few have reported relevant data. The intra-observer differences were almost all less than 3 months in the study of Sproul and Peritz.[180] Moore[170] reported interobserver differences that were less than 12 months in 94 percent of bones.

Factors Influencing Replicability

There is no indication that the level of replicability is related to the difference between chronological and skeletal age.[173,176] However, the range of maturity between the bones of a hand-wrist influences the replicability of overall but not bone-specific assessments.[8,173] The quality of the radiographs (exposure, positioning) has no effect on replicability within the range usual in research studies,[8] but unusually poor radiographic quality does reduce replicability.[176] The method by which the Greulich-Pyle Atlas is used has an effect. Maresh[23] reported a technical error of 3.0 months between overall assessments and those obtained as the means of bone-specific skeletal ages. The direction of these differences was not reported. Peritz and Sproul[77] considered assessment more difficult in short or tall children and in the hamate and second metacarpal than in other hand-wrist bones. The latter statement has not been confirmed in the Health Examination Survey on either self- or cross-replication data.

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☆ U. S. GOVERNMENT PRINTING OFFICE : 1975 210-981/8

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NCHS

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Public Health Service
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