AN EVALUATION OF THE COURTIS METHOD IN THE STUDY OF GROWTH RELATIONSHIPS

Thesis for the Degree of Ph. D.

MICHIGAN STATE UNIVERSITY

Gerald H. Wohlferd

1957

This is to certify that the

thesis entitled

[illegible]

[illegible]

presented by

Gerald H. [illegible]ohlford

has been accepted towards fulfillment
of the requirements for

Ph.D. **degree in** Education

Major professor

Date Dec. [illegible], 1957

O-169

AN EVALUATION OF THE COURTIS METHOD IN THE STUDY OF GROWTH RELATIONSHIPS

by

Gerald H. Wohlferd

AN ABSTRACT

Submitted to the School of Graduate Studies of Michigan
State University of Agriculture and Applied Science
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

School of Education

1957

Approved: Cecil V. Millard

This study was conducted to test the accuracy with which the Courtis method described height and weight growth, to test the use of correlative procedures on derivations of this technique, and to use extrapolation to arrive at new insights into growth.

All cases used in this study were selected from the Dearborn Data which is available at the Michigan State University. All cases selected met the criteria that, measures must be included in a span of from ninety-six months through 180 months, and each pre-adolescent and adolescent cycle must contain at least three measures of both height and weight. The measures of twenty-six boys and eighteen girls met the above criteria.

Height and weight growth equations were written for each case by use of the Courtis method. Predicted measures were fitted as closely as possible to actual measures.

Cyclic starting and ending times were obtained by substituting the isocronic values for one per cent and 99 per cent respectively, for 'y' in the above equations and solving for 't'. Values attained at one per cent of the adolescent cycle were obtained by substituting age at one per cent for 't' in the pre-adolescent equation and solving for 'y'. Percentages of development were obtained by dividing derived scores by proper maxima.

The Courtis method describes growth in height and weight well within a two per cent average deviation. Height growth was described more accurately than weight growth. The Courtis method describes height and weight growth so accurately that it may be used to test for growth relationships through various statistical techniques.

Correlations between rates, maxima, ages at one per cent of adolescent growth, 99 per cent of pre-adolescent growth, 99 per cent of adolescent growth, and percentages of development at the beginning of the adolescent cycles were generally positive, but too low for predictive use.

Negative correlations obtained when pre-adolescent height and weight maxima were correlated with respective adolescent height and weight maxima seemed to indicate that large pre-adolescent maxima are followed by smaller adolescent maxima and vice versa.

Correlations derived between values of height and weight attained at one per cent of the adolescent cycle and corresponding total maxima tended to verify the above conclusion.

The use of the Courtis method to find growth relationships through correlative techniques did not produce outstanding results. Correlations obtained between final maxima were no better than those noted in the Review of Literature.

Curves of constants revealed the earlier maturing of girls, while curves of percentages of development disclosed similarities of adolescent starting ages and percentages of total development at the beginning of adolescent growth.

Means of starting times, of pre-adolescent height growth attained when the adolescent cycle began, and of percentages of total growth attained at the beginning of adolescent growth, showed great similarities between height and weight values of each sex. The probability of the existence of equal height and weight adolescent cycle beginning points is evidenced by the small deviations of the above means.

AN EVALUATION OF THE COURTIS METHOD IN THE STUDY OF GROWTH RELATIONSHIPS

by

Gerald H. Wohlferd

A THESIS

Submitted to the School of Graduate Studies of Michigan
State University of Agriculture and Applied Science
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

School of Education

1957

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

PROBLEM AND DEFINITION OF TERMS

Introduction

The relationships between height and weight are interesting to many people. Parents discuss the progress their off-spring are, or have been making. They compare them with siblings and other children. They even recall and use as a yardstick their own progress as children. The children, themselves, in their society compare themselves with their peers. Who has not heard the derisive, "Pick on someone your own size"? Young adolescent girls often complain that boys of similar chronological age are "too short for me."

The business world is interested in the size of humans. Ever since the industrial revolution and the beginning of mass production of clothing, sizes have been attached to facilitate sales.[1] Penny weight scales have norms for height and weight prominently displayed. Telephone booths, car,[2] train, bus, and airplane seats,

---

[1]Margaret Dana, _Behind the Label_ (Boston: Little, Brown and Company, 1938), p. 127.

[2]Edwin C. Pickard, Ford Motor Company Engineer, _A Passenger Car Comfort and Seat Design_ (paper presented at SAE meeting, 1956).

theatre seats,[3] doorways, step heights, and hosts of other manufactured items are constructed according to norms established by careful research.[4]

Advertising companies day after day announce the nutritional growth producing values of breakfast cereals, breads, candies, drinks and a wide range of pills, vitamins, and various sundry nostrums.

School desks, chairs and tables are now adjustable and scaled to fit different grade levels. Blackboards, sinks, toilets, pencil sharpeners, and drinking fountains are installed within reach of desired grade ranges.

Scientists, too, are interested in height-weight relationships, and have suggested numerous ways of describing and predicting growth.[5]

I. STATEMENT OF THE PROBLEM

General Statement

Courtis[6] postulates the idea that growth can be accurately described by the mathematical equation

---

[3]American Seating Company, Better Seating for America Through Research, Testing, Inspection, Grand Rapids, Michigan, 1953.

[4]"Basic Body Measurements of School Age Children," U. S. Department of Health, Education and Welfare, June, 1953.

[5]See "Review of the Literature" Chapter II.

[6]S. A. Courtis, Towards A Science of Education (Ann Arbor, Michigan: Edwards Bros., 1951), pp. 13-16.

$y = k\ [\ rt \pm i]$, and that different elements, or constants, of the equation lend themselves to mathematical comparison.

The purpose of this study is (1) to evaluate the accuracy with which height and weight growth is described by the Courtis method, (2) to test the application of correlative procedures to Courtis equation derivations, and (3) to show the extent to which extrapolation may be used to arrive at new insights into growth.

Specific Statement

Specifically, this investigation has the following major objectives:

1. To determine the deviation of predicted measures from actual measures.
2. To obtain correlations between like constants, as below, for each sex:
    - a. r_1 height with r_1 weight
    - b. r_2 height with r_2 weight
    - c. r_1 height with r_2 height
    - d. r_1 weight with r_2 weight
    - e. k_1 height with k_1 weight
    - f. k_2 height with k_2 weight
    - g. k_3 height with k_3 weight
    - h. k_1 height with k_2 height
    - i. k_1 height with k_3 weight
    - j. k_2 height with k_3 height
    - k. k_1 weight with k_2 weight

l. k_1 weight with k_3 weight

m. k_2 weight with k_3 weight

n. b_1 height with b_1 weight

o. t_1 height with t_1 weight

p. t_2 height with t_2 weight

q. t_1 height with t_2 height

r. t_1 weight with t_2 weight

s. c_1 height with c_1 weight

t. c_1 height with k_2 height

u. c_1 weight with k_2 weight

v. c_1 height with k_3 height

w. c_1 weight with k_3 weight

x. d_1 height with d_1 weight

y. d_2 height with d_2 weight

z. d_1 height with d_2 height

* d_1 weight with d_2 weight

3. To use extrapolation:

   a. To determine curves of constants for measures of height and weight, for each sex.

   b. To determine curves of constants for percentages of total maturity of height and weight, for each sex.

   c. To determine the mean age at which the adolescent height and weight cycles begin for each sex.

      (1) To determine the deviations from the mean of the above beginning ages.

d. To determine the mean percents of pre-adolescent height and weight development attained when the adolescent cycle begins for each sex.

  (1) To determine the deviations from the mean of the above beginning percentages.

e. To determine the mean per cent of total height and weight maturity attained when the adolescent cycle begins.

  (1) To determine the deviations from the mean of the above percentages.

II. IMPORTANCE OF THE STUDY

Courtis postulates a natural law, and asserts that all living matter follows such a law. He maintains that all living things grow in a cyclic fashion according to predictable rules. His mathematical description of the universal law of growth is $Y = ki^{r^t}$, a function of the Gompertz curve. He has tested this formula on the growth patterns of living organisms of many kinds and feels that such studies have borne out its validity.[7]

He suggests that interrelationships exist between the constants of the equations. Furthermore, he states

---

[7] S. A. Courtis, Maturation Units and How to Use Them (Ann Arbor, Michigan: Litho-printed, Edwards Bros., 1950), Appendix C.

that these constants can be computed from three reliably determined points on a maturation curve, and that the equation so derived will describe a curve which deviates less than two per cent from the actual measurements.[8]

Courtis feels that many past educational studies are unscientific, and debunks them as having "the dry rot of meaningless juggling of statistical symbols." He then states:

> The glory of science is that it is man's only way to determine, objectively, whether a given idea is true or false.
>
> On the basis of scientific truth man is able to predict and control. That is true "which works."[9]

If his method "works," then it is worthwhile using his technique to search for growth relationships or other insights into the developmental pattern of human growth.

III. DEFINITION OF TERMS USED

Development. The progress towards maturity brought about in an immature organism by the action of appropriate environmental forces under constant conditions.[10] In

---

[8]Courtis, Toward A Science of Education, op. cit.,p.1.

[9]Courtis, Maturation Units and How to Use Them, op. cit., p. 129.

[10]Courtis, Towards A Science of Education, op. cit., p. 9.

actual practice, growth, development and maturation are used interchangeably depending upon the emphasis desired.[11]

Growth cycle. A well marked period of maturation during which the organism, forces, and end products are constant.[12]

Maximum. The ultimate state or condition within a specific cycle.[13]

Maturity. The maximum of development related to a specific growth and situation; e.g., physical maturity is factor "k" of the Gompertz function.[14]

Pre-adolescence and adolescence. There are two periods of rapid growth, with one period between of slower growth. The periods of rapid growth are early infancy and adolescence. The period of less rapid growth is late childhood or . . . . (pre-adolescence).[15]

---

[11]Courtis, *Maturation Units and How to Use Them*, *op. cit.*, p. 129.

[12]Courtis, *Towards A Science of Education*, *op. cit.*, p. 13.

[13]Rueben R. Rusch, "The Relationship Between Growth in Height and Growth in Weight" (unpublished M.A. thesis, Department of Education, Michigan State College, 1954).

[14]Ekanem A. Udoh, "Relationship of Menarch to Achieved Growth in Height" (unpublished Ph.D. thesis, Department of Education, Michigan State College, 1955).

[15]C. V. Millard, *Child Growth and Development* (Boston: D. C. Heath and Company, 1951), p. 65.

The term adolescence is . . . . a period during which the growing person makes the transition from childhood to adulthood.[16]

The Gompertz functions.[17] $y = ke^{ce^{at}}$ or $y = ki^{r^t}$ where:

y = achieved development at time "t."

k = maximum towards which development is progressing.

e^c = incipiency (i) or the degree of development at the beginning of the period of growth.

e^a = rate (r) of growth expressed in isochrons.

Isochron.[18] One per cent of the time necessary for the generation of the Gompertz Function from 0.000000189 per cent to 99.90917 per cent.

Constants. Maximum, rate and incipiency.

---

[16] Arthur T. Jersild, The Psychology of Adolescence (New York: The Macmillan Company, 1957), p. 4.

[17] Gerald T. Kowitz, "An Exploration into the Relationship of Physical Growth Pattern and Classroom Behavior in Elementary School Children" (unpublished Ph.D. thesis, Department of Education, Michigan State College, 1954).

[18] Courtis, Maturation Units and How to Use Them, op. cit., p. 140.

Symbols employed.

r_1 = rate of pre-adolescent cycle.

r_2 = rate of adolescent cycle.

k_1 = maximum of pre-adolescent cycle.

k_2 = maximum of adolescent cycle.

k_3 = total maturity.

b_1 = age at 1 per cent of adolescent cycle.

t_1 = age at 99 per cent of pre-adolescent cycle.

t_2 = age at 99 per cent of adolescent cycle.

c_1 = value at 1 per cent of adolescent cycle.

d_1 = per cent of pre-adolescent cycle attained at the beginning of the adolescent cycle.

d_2 = per cent of total maturity attained at the beginning of the adolescent cycle.

CHAPTER II

REVIEW OF THE LITERATURE

The study of the human body is no new fad. Physical growth was of early scientific interest. Buffon,[19] in 1837 reported studies conducted during 1759-1776. Measuring instruments and techniques, however, were crude. Quetelet,[20] who is also credited with origination of the term 'anthropometry', first standardized a method for studying physical growth. Since then, due to the efforts of Hrdlicka[21] and others,[22,23,24,25,26,27] measurement of the human body has become common.

---

[19]Count de Buffon, "Sur l'accroissement successif des enfants, Gueneau de Montbeillard mesure de 1759 a 1776," Oeuvres Completes (Paris: Furne and Pie, 1837), Vol. III, pp. 174-176.

[20]A. Quetelet, Anthropometrie (Bruxelles: Muquardt, 1871).

[21]Ales Hrdlicka, Practical Anthropometry (Philadelphia: Wister Institute of Anatomy and Biology, 1920), pp. x-230.

[22]M. P. Baum, and V. S. Vickers, "Anthropometric and Orthopedic Examinations: A Technique for Use with Children," Child Development Monographs, 1941, Vol. 12, No. 4, pp. 339-345.

[23]L. M. Bayer and N. Bayley, "Directions for Measures and Radiographs Used in Predicting Height," Child Development Monographs, 1947, Vol. 18, No. 3, pp. 85-87.

Studies of physical growth became so numerous in the following years that in 1921 Baldwin[28] met the pressing need for syntheses by publishing a summary of previous works. Many other bibliographies[29,30,31,32,33] have

---

[24]W. F. Dearborn and J. W. M. Rothney, _Predicting the Child's Development_ (Cambridge, Mass.: Sci-Art Pub., 1941), Chapter 4.

[25]V. B. Knott, "Physical Measurement of Young Children," _University of Iowa Studies: Studies in Child Welfare_, 1941, Vol. 18, No. 3.

[26]W. M. Krogman, "A Handbook of the Measurement and Interpretation of Height and Weight in the Growing Child," _Monograph of the Society for Research in Child Development_, 1948, Vol. 13, No. 3, pp. ix-68.

[27]H. C. Stuart and Staff, "The Center for Research in Child Health and Development, School of Public Health, Harvard University, I," _Monograph of the Society for Research in Child Development_, 1939, Vol. 4, No. 1, pp. xiv-261.

[28]B. T. Baldwin,"The Physical Growth of Children from Birth to Maturity," _University of Iowa Studies of Child Welfare_, 1921, Vol. 1, No. 1.

[29]Children's Bureau of the United States Department of Labor, _References on the Physical Growth and Development of the Normal Child_, 1927, No. 179.

[30]Howard V. Meredith, "Physical Growth of White Children, A Review of American Research Prior to 1900," _Monograph of the Society for Research in Child Development_, 1936, Vol. I, No. 2, pp. 1-83.

[31]H. E. Jones, "Relationships in Physical and Mental Development," _Review of Educational Research_, 1933, No. 3, pp. 150-162.

[32]H. V. Meredith and G. Stoddard, "Physical Growth from Birth to Maturity," _Review of Educational Research_, 1936, Vol. 6, pp. 54-84.

subsequently been published and references are now kept current through 'Child Development Abstracts,' which began publication in 1927.

Child development as a scientific endeavor began in the 1920's with the establishment of research centers in America, whose purpose was the collection and processing of data concerning all phases of human development. Some of the more important of these are: Harvard University Center for Research in Child Health and Development, 1922; University of California Institute of Child Welfare, 1922; University of Minnesota Institute of Child Welfare, 1922; Yale Institute of Human Development, 1925; Fels Institute, Antioch College, 1929; and Brush Foundation, Western Reserve College, 1931.

As child development research increased in volume, the method of study changed. Pioneers in the field of human growth wrote biographical accounts of individual children, usually their own.[34] From these early sketches, developmental studies resolved into a type of study known as the 'cross-sectional' method. This procedure utilized the collection of data on ". . . large groups of children

---

[33]W. M. Krogman, "The Physical Growth of Children: An Appraisal of Studies 1950-1955," Monographs of the Society for Research in Child Development, Inc., 1956, Vol. 20, No.60, pp. iii-91.

[34]L. K. Frank, Child Behavior and Development, edited by Barker, Kounin and Wright.(New York: McGraw-Hill Book Company, Inc., 1943), p. 1.

of different age periods and aggregating the observations and measurements of this large array of subjects.[35]

Cross-sectional data lends itself particularly well to the use of statistical techniques and those doing research in child development made use of these in analysis. Many valuable generalities have been arrived at through this type of study.[36,37,38,39,40]

The publication of height-weight norms in both non-professional[41] and scientific,[42,43,44] journals is an

---

[35] Ibid., pp. 10.

[36] Arnold Gesell and Catherine S. Amatruda, Developmental Diagnosis (New York: Paul B. Hoeber, Inc., 1952), p. 496.

[37] Norman L. Munn, The Evolution and Growth of Human Behavior (New York: Houghton Mifflin Company, 1955),p.525.

[38] Hilde Bruch, "Obesity in Childhood: I. Physical Growth and Development of Obese Children," American Journal of Diseases of Children, Vol. 58, No. 3, pp. 457-484.

[39] Ethel M. Abernethy, "Relationships Between Mental and Physical Growth," Monographs of the Society for Research in Child Development, Vol. 1, No. 7, pp. vii-80.

[40] Ruth Strang, An Introduction to Child Study (New York: The Macmillan Company, 1951), p. 705.

[41] Andrew Hamilton, "You Can Tell Now How Tall Your Child Will Grow," Colliers, August 9, 1952.

[42] Maury Massler, "Calculation of Normal Weight," Child Development Monographs, 1945, Vol. 16, Nos. 1 and 2.

[43] Helen B. Pryor, "Width-Weight Tables (Revised)," American Journal of Diseases of Children, Vol. 61, pp. 300-304.

expression of the universal interest in height-weight relationships.

Wood[45] published in 1910 the first height-weight norms to receive general attention. In 1914 Baldwin[46] was able to report on two hundred height-weight relationship studies. Baldwin, Wood and Woodbury[47] published a revised table in 1940; Steggerda[48] constructed tables using Navaho Indians and Holland (Michigan) whites in 1936. Simmons and Todd[49] used Cleveland children in their study in 1938. Todd,[50]

---

[44] W. Kornfield, "Technical Aspects of the Analysis of Bodily Conformation in Children," _American Journal of Diseases of Children_, Vol. 55, pp. 835.

[45] T. D. Wood, "Health Examination," Ninth Yearbook, _National Society for the Study of Education_, 1910, Vol. 9, Part 1, pp. 34-35.

[46] B. T. Baldwin, "Physical Growth and Progress," _Bulletin 10; U. S. Bureau of Education_, Washington, D. C., 1914.

[47] B. T. Baldwin, _et al, Height-Weight Age Tables_ (New York: American Child Health Association, 1923).

[48] M. Steggerda, "A Height-Weight-Age Table for Navahoes 6-18 Years; a Height-Weight-Age Table for Dutch Whites, 6-15 Years, Measured in Holland, Mich.," (Washington, D.C.: Carnegie Institute, 1936).

[49] K. Simmons and T. W. Todd, "Growth of Well Children: Analysis of Stature and Weight, Three Months to Thirteen Years," _Growth_, 1938, Vol. 2, p. 130.

[50] _Ibid._, pp. 93-134.

Meredith,[51] Shuttleworth,[52] and others[53,54] have also worked with physical growth norms.

A definite relationship between different types of human growth has been long and ardently sought. Correlation studies abound in past and current literature, and the areas of height and weight have received considerable attention. Though Simmons[55] found some fairly high correlations (ranging from .399 to .814) between height and weight, McCloy[56] (r = .587), Jackson[57] (r = .52),

---

51Howard V. Meredith and Matilda E. Meredith, "Annual Increment Norms for Ten Measures of Physical Growth on Children Four to Eight Years of Age," Child Development Monographs, Vol. 21, No. 33.

52Frank K. Shuttleworth, "Standard of Development in Terms of Increments," Child Development Monographs, 1934, No. 1, pp. 89-91.

53Medora B. Grandprey, "Range of Variability in Weight and Height of Children Under Six Years of Age," Child Development Monographs, 1933, No. 1, pp. 26-35.

54Susan P. Souther, et al, "A Comparison of Indices Used in Judging the Physical Fitness of School Children," American Journal of Public Health, 1939, Vol. 29, pp.434-438.

55Katherine Simmons, "The Brush Foundation Study of Child Growth and Development: II. Physical Growth and Development," Monograph of the Society for Research in Child Development, 1944, Vol. 9, No. 1, p. 53.

56Charles H. McCloy, "Appraising the Physical Status--The Selection of Measurements," University of Iowa Studies, Vol. 12, No. 2, p. 59.

57C. M. Jackson, "Normal and Abnormal Human Types," Measurement of Man (Minneapolis, Minnesota: University of Minnesota Press, 1930), Vol. 86.

Miller[58] (r = .63), and Dearborn and Rothney[59] (r = .68) bear out Millard's[60] statement that correlations are positive ". . . but too low to indicate much relationship."

But, many scientists felt that the 'normal' person is a non-entity, and that cross-sectional methods used to find the hypothetical normal person actually hide individual traits.[61,62,63] They, therefore, proposed that each individual included in a study be observed over a period of time. This technique--the longitudinal method--immediately proved of value. The theory that a growth pattern

---

[58]R. Bretney Miller, "Physique, Personality and Scholarship, A Comparative Study of School Children," Monograph of the Society for Research in Child Development, 1943, Vol. VIII, No. 1, p. 57.

[59]W. F. Dearborn and J. W. M. Rothney, Predicting the Child's Development (Cambridge, Massachusetts: Sci-Art Publishers, 1941), p. 293.

[60]Millard, op. cit., p. 31.

[61]William W. Greulich, "Some Observations on the Growth and Development of Adolescent Children," The Journal of Pediatrics, 1941, Vol. 19, pp. 302-314.

[62]Franz Boaz, "Observations on the Growth of Children," Science, July, 1930, Vol. 72, pp. 44-48.

[63]A. R. DeLong, "The Relative Usefulness of Longitudinal and Cross-Sectional Data," (paper presented to the Michigan Academy of Science, Arts, and Letters, March 26, 1955).

is not a single cycle phenomena was soon to be challenged.[64,65,66,67,68] Courtis,[69] Millard,[70] Bayley,[71] and Gray[72] suggest that growth in height and weight is multi-cyclic in pattern.

No real ultimate in the education and understanding of children can be reached, however, until the growth of children in all facets of life may be predicted accurately.

---

[64]Meredith, op. cit., pp. 1-83.

[65]Ruth S. Wallis, "How Children Grow, An Anthropometric Study of Private School Children From Two to Eight Years of Age," University of Iowa Studies in Child Welfare, Vol. 5, No. 1, p. 73.

[66]George Wolff, "A Study of Height in White School Children from 1937 to 1940 and a Comparison of Different Height-Weight Indices," Child Development Monographs, Vol 13, No. 1, pp. 65-77.

[67]Howard V. Meredith, "The Rhythm of Physical Growth," University of Iowa Studies, 1935, Vol. 11, No. 3, p. 232.

[68]C. B. Davenport, "Human Growth Curve," Journal of General Physiology, 1926, Vol. 10, pp. 205-216.

[69]S. A. Courtis, "Maturation as a Factor in Diagnosis," The 34th Yearbook of the Society for the Study of Education, 1935,pp.169-187.

[70]A. J. Huggett and C. V. Millard, Growth and Learning in the Elementary School (Boston: D. C. Heath and Company, 1946), p. 39.

[71]Nancy Bayley, Studies in the Development of Young Children (Berkeley, California: University of California Press, 1940), p. 13.

[72]H. Gray, "Individual Growth-Rates: From Birth to Maturity for Fifteen Physical Traits," Human Biology, 1941, Vol. 13, No. 3, pp. 306-333.

Numerous procedures have been offered to this end, though most are of interest only to the scientist and are impractical for classroom use. Todd,[73] Flory,[74] Bayley,[75] and Greulich[76] have published detailed descriptions of the development of bone in the skeleton (principally the wrist joint). Wetzel[77] constructed an easy to use graphical presentation of growth from which he claimed to be able to determine physical fitness.[78,79]

---

[73]Wingate T. Todd, *Atlas of Skeletal Maturation* (St. Louis, Missouri: Mosby Publishing Co., 1937).

[74]C. D. Flory, "Osseos Development in the Hand as an Index of Skeletal Development," *Monographs of the Society for Research in Child Development*, Vol. 1, No. 3, pp. ix-141.

[75]Nancy Bayley, "Tables for Predicting Adult Height from Skeletal Age and Present Height," *Journal of Pediatrics*, Vol. 28, 1946, pp. 49-64.

[76]W. W. Greulich. "The Rationale of Assessing the Developmental Status of Children from Roentgenograms of the Hand and Wrist," *Child Development*, 1950, Vol. 21, pp. 33-44.

[77]Norman C. Wetzel, *The Treatment of Growth Failure in Children* (Cleveland, Ohio: NEA Service, Inc., 1948).

[78]H. J. Leeson, *et al*, "The Value of the Wetzel Grid in the Examination of School Children," *Canadian Journal of Public Health*, 1947, Vol. 38, pp. 491-495.

[79]S. M. Garn, "Individual and Group Deviations from 'Channelwise' Grid Progression in Girls," *Child Development, Monographs*, Vol. 23, No. 3, September, 1952, pp. 193-206.

Meredith[80] made a 'T' score graph from data collected on Americans of North European parentage that he feels offers a reasonably refined instrument for predicting the stature of public school children of white North European ancestry. Sheldon[81] divided the human physique into three body types: mesomorphic, ectomorphic, and endomorphic. Stolz and Stolz[82] used these divisions in studying physical development of boys. Jens and Bayley[83] reported on a mathematical equation developed by L. S. Reed of Johns Hopkins University for the description of growth, and found it could be used to compare several characteristics of growth in children.

A technique for predicting body weight has been worked out by Dearborn and Rothney,[84] which they claim to be twenty per cent more effective than ordinary height-weight

---

[80]H. V. Meredith, "The Prediction of Stature of North European Males Throughout the Elementary School Years," _Human Biology_, 1938, Vol. 8, No. 2, pp. 279-283.

[81]W. H. Sheldon, _et al_, _The Varieties of Human Physique_ (New York: Harper Brothers, 1940), p. 5.

[82]Herbert R. Stolz and Lois M. Stolz, _Somatic Development of Adolescent Boys_ (New York: The Macmillan Company, 1951), pp. xxxiv-557.

[83]R. N. Jens and Nancy Bayley, "A Mathematical Method for Studying the Growth of a Child," _Human Biology_, 1937, Vol. 9, pp. 556-563.

[84]W. F. Dearborn and J. W. M. Rothney, "Basing Weight Standards Upon Linear Bodily Dimensions," _Growth_, 1938, Vol. 2, No. 2, pp. 197-212.

tables. Through the use of their method, they obtained a correlation of .676 between height and weight.[85] Other methods of description and prediction of growth are reviewed by Shock.[86]

Olson and Hughes[87] have devised a method by which various types of growth are converted to comparable age units, thus making simple the comparison of growth patterns. The "Organismic Age" concept of growth, as advanced by them suggests that all types of growth are related.

Bloomers[88] after studying the "Organismic Age" theory, and applying it to selected data, agreed that "there is some relatedness in rate of growth among various physical measures." A correlation of .57 was obtained by him between height age and weight age.

Tyler[89] in 1953 attacked the organismic age theory on the basis of the variability of the rates, and starting

---

[85]Dearborn, _Predicting the Child Development_, _op. cit._, p. 270.

[86]N. S. Shock, "Growth Curves," _Handbook of Experimental Psychology_ (New York: John Wiley, 1951), Chapter 10.

[87]W. C. Olson and B. O. Hughes, "Growth of the Child as a Whole," _Child Behavior and Development_, edited by Barker, Kounin, and Wright (New York: McGraw-Hill Book Company, 1943), Chapter 8.

[88]P. Bloomers, _et al_, "The Organismic Age Concept," _Journal of Educational Psychology_, 1955, Vol. 46, pp.142-148.

[89]Fred T. Tyler, "Concepts of Organismic Growth: A Critique," _Journal of Educational Psychology_, 1953, Vol. 44, pp. 321-342.

and ending points of the various converted growth ages. Yet, a few years later he writes:

> No doubt there are important relationships among growth of testes and certain other aspects of growth or development or learning. These related characteristics are more likely to be in the realm of physical growth, and possibly in social and emotional learning rather than in acedemic learning. . . .[90]

Stroud,[91] too, felt there is a relationship between various factors of growth. He suggests this is probably due to heredity and possibly to a fairly constant environment.

It remained for Courtis[92,93,94,95] to advance to a more accurate description of growth. By using a function

---

[90]Fred T. Tyler, "Organismic Growth: Sexual Maturity and Progress in Reading," Journal of Educational Psychology, 1955, Vol. 46, pp. 85-93.

[91]J. B. Stroud, Psychology in Education (New York: Longmans, Green and Company, 1956), pp. 241-257.

[92]S. A. Courtis, The Measurement of Growth (Ann Arbor, Michigan: Brumfield and Brumfield, 1932), pp. 155-162.

[93]S. A. Courtis, "What Is A Growth Cycle?," Growth, 1937, Vol. 1, No. 4, pp. 155-174.

[94]S. A. Courtis, "Maturation Units for the Measurement of Growth," School and Society, 1929, Vol. 30, pp. 683-690.

[95]Courtis, Maturation Units and How to Use Them, op. cit., pp. 1-95.

of the Gompertz equation,[96,97,98] Courtis was able to mathematically describe growth of all types. Millard,[99,100] early experimented with the accuracy of this method, and has offered convincing evidence of the applicability of this method.

Some authors have raised questions about the accuracy and application of the Courtis technique. Flanagan[101] offers the following observations about the Courtis method:

> These units (isocrons) appear to offer simplicity and comparability. The principal disadvantage is the complexity of the functions to be measured in education. . . . Another very serious practical limitation is the difficulty in identifying the upper limit to be used in defining complete maturity.

---

[96] C. P. Winsor, "The Gompertz Curve as a Growth Curve," Proceedings of the National Academy of Sciences, 1932, Vol. 18, No. 1, pp. 1-8.

[97] R. D. Prescott, "Law of Growth in Forecasting Demand," Journal of the American Statistical Association, 1922, Vol. 18, No. 140, pp. 471-479.

[98] F. E. Croxton and D. J. Cowder, Applied General Statistics (New York: Prentice-Hall, Inc., 1939), pp. 447-452.

[99] C. V. Millard, "The Nature and Character of Pre-Adolescent Growth in Reading Achievement," Child Development, Monographs, Vol. 11, No. 2, 1940, pp. 71-114.

[100] C. V. Millard, "An Analysis of Factors Conditioning Performance in Spelling" (unpublished Ph.D. thesis, School of Education, University of Michigan, 1937).

[101] J. C. Flanagan, "Units, Scores, and Norms," Educational Measurement, ed. E. F. Lindquist (Washington, D.C.: American Council of Education, 1951), p. 722.

> There are very few areas in which any one ever attains complete maturity. It is also extremely difficult to place the zero point in a practical situation. Therefore, although learning expressed in equal time units appears at first consideration to be an excellent idea, it does not seem practical for the typical kinds of educational measurement in current use.

Tyler[102] discusses the Courtis method indirectly in a critique on Millard's work with height and reading relationships. One of his objections has to do with the difficulty of obtaining in our present schools, the necessary measurements from which to base the determination of the age at which the child would begin to read. Another deals with the use of "extrapolation" in determining beginning and ending points of cycles.

The use of extrapolation, from derived Courtis equations to obtain figures, which are not obtainable by direct measurement, is upheld by Dearborn and Rothney[103] in their exhaustive study of the prediction of development in children. The foregoing authors offered another method for obtaining the maxima, which they felt to be a more accurate, though more time consuming procedure.

Meredith[104] attempted to apply the Courtis method to test its usefulness on six selected cases using only

---

[102] Tyler, "Concepts of Organismic Growth," _op. cit._, pp. 321-342.

[103] Dearborn and Rothney, _Predicting the Child's Development_, _op. cit._, pp. 213-237.

[104] Meredith, "The Rhythm of Physical Growth," _op. cit._, p. 120.

three measures each, between the ages of seven years and nine years, nine months. He reported his results as follows:

> Critical evaluation is made of the . . . Courtis "universal law" method of prediction individual growth . . . (and) is considered unsuited to the prediction of individual growth in stature for white males between six and eleven years.

Nally and DeLong[105] reworked Meredith's data and found errors of computation which caused him to find erroneous maxima. From the results of their study, Nally and DeLong concluded, "that Courtis' law of growth is applicable for the prediction of growth in stature with an accuracy that is within rigorous scientific limits. . . ."

Doctoral candidates at Michigan State University have used the Courtis method. Nally[106] employed this technique in suggesting that reading achievement and height of children have a definite relationship. Kowitz[107] applied this method to social ranking and developmental

---

[105]T. P. Nally and A. R. DeLong, "An Appraisal of a Method of Predicting Growth," Series II, No. 1 (East Lansing, Mich.: Child Development Laboratory, 1952).

[106]T. P. F. Nally, "The Relationship Between Achieved Growth in Height and the Beginning of Growth in Reading" (unpublished Ph.D. thesis, Department of Education, Michigan State College, 1953).

[107]Kowitz, op. cit.

height and weight to demonstrate its use still further. Rusch[108] also established broad relationships between height and weight. Udoh[109] found relationships between maturity in height growth and advent of menarche in girls.

---

[108]Rusch, _op. cit_.

[109]Udoh, _op. cit_.

CHAPTER III

PROCEDURE

Data

The data used in this study were taken from material available in the Child Development Laboratory at Michigan State University. The forty-four cases, twenty-six boys and eighteen girls, are part of approximately three hundred children of the Dearborn, Michigan study. Data on these children were obtained by teachers trained in techniques of proper measurement, under the directon of Dr. C. V. Millard.

Cases used in this study were selected to fit the following criteria: (1) Measures to include a span of from 96 months through 180 months. This age range was chosen so that the material would encompass two cycles of growth.[110] (2) When plotted upon logarithmic graph paper each cycle must have contained three measures of both height and weight in both the pre-adolescent and the adolescent cycles of growth. No attempt was made to obtain a random sample.

---

[110] Millard, Child Growth and Development in the Elementary School, op. cit., p. 65.

Figure 1 shows a summary of the magnitude of measures of height and weight. A detailed tabulation of each individual case, including the range of the measures, may be found in Appendices A and B.

The boys of this study have an average I.Q. of 106.7, and the girls an average I.Q. of 107.1; resulting in a combined average I.Q. of 106.8. Figure 2 is a frequency histogram showing the distribution of I.Q.'s. Individual I.Q.'s may be found in Appendix C. The standard deviation for the total I.Q.'s is 9.2, which shows a close grouping within the ranges of average intelligence.

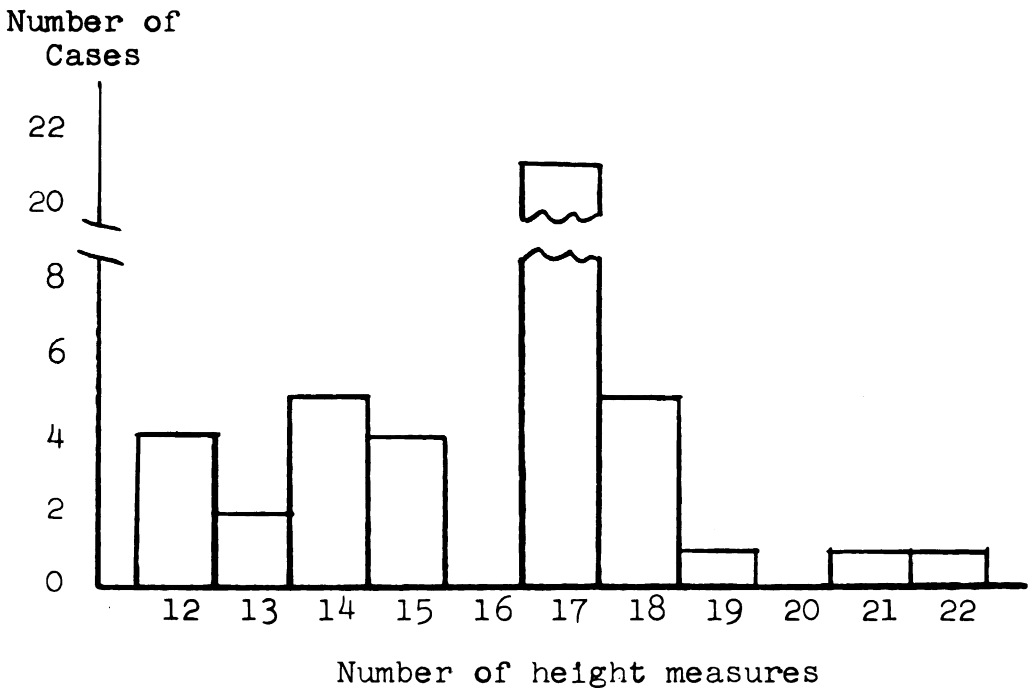
The parents of the children of the Dearborn study were found to fit the Class IV grouping of the Sims[111] socio-economic rating scale which was administered to them. This grouping, which consists of skilled laborers working for someone else, building trades, transportation trades, and manufacturing trades involving skilled labor, coincides with Terman's[112] rating of Class III. Forty-five per cent of our national population falls within this classification according to Terman.[113] The Terman Class III

---

[111] Verner M. Sims, The Measurement of Socio-Economic Status (Bloomington, Illinois: Bloomington Public Schools Publishing Company, 1928), *passim*.

[112] Lewis M. Terman and Maud A. Merrill, *Measuring Intelligence* (Boston: Houghton Mifflin Company, 1939), p. 48.

[113] *Ibid*.



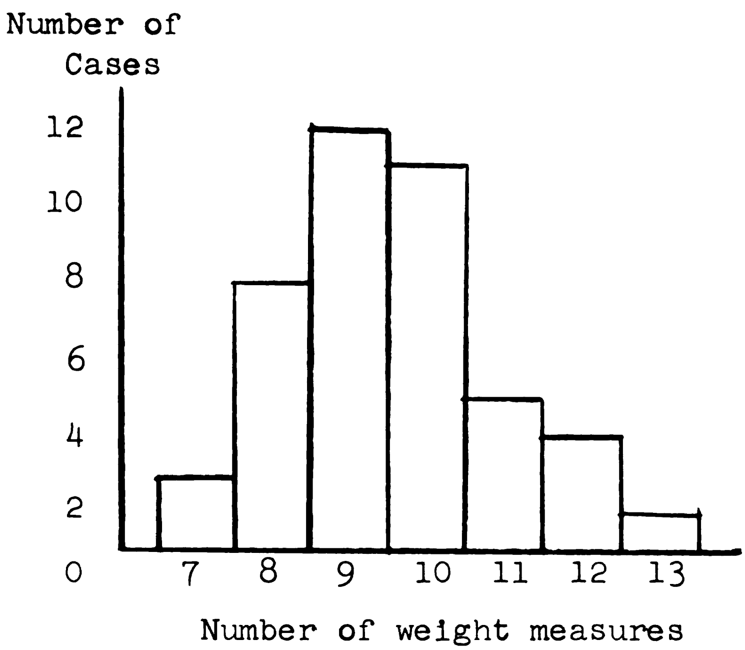


Figure 1. Number of Measures Including Both Sexes and Both Cycles

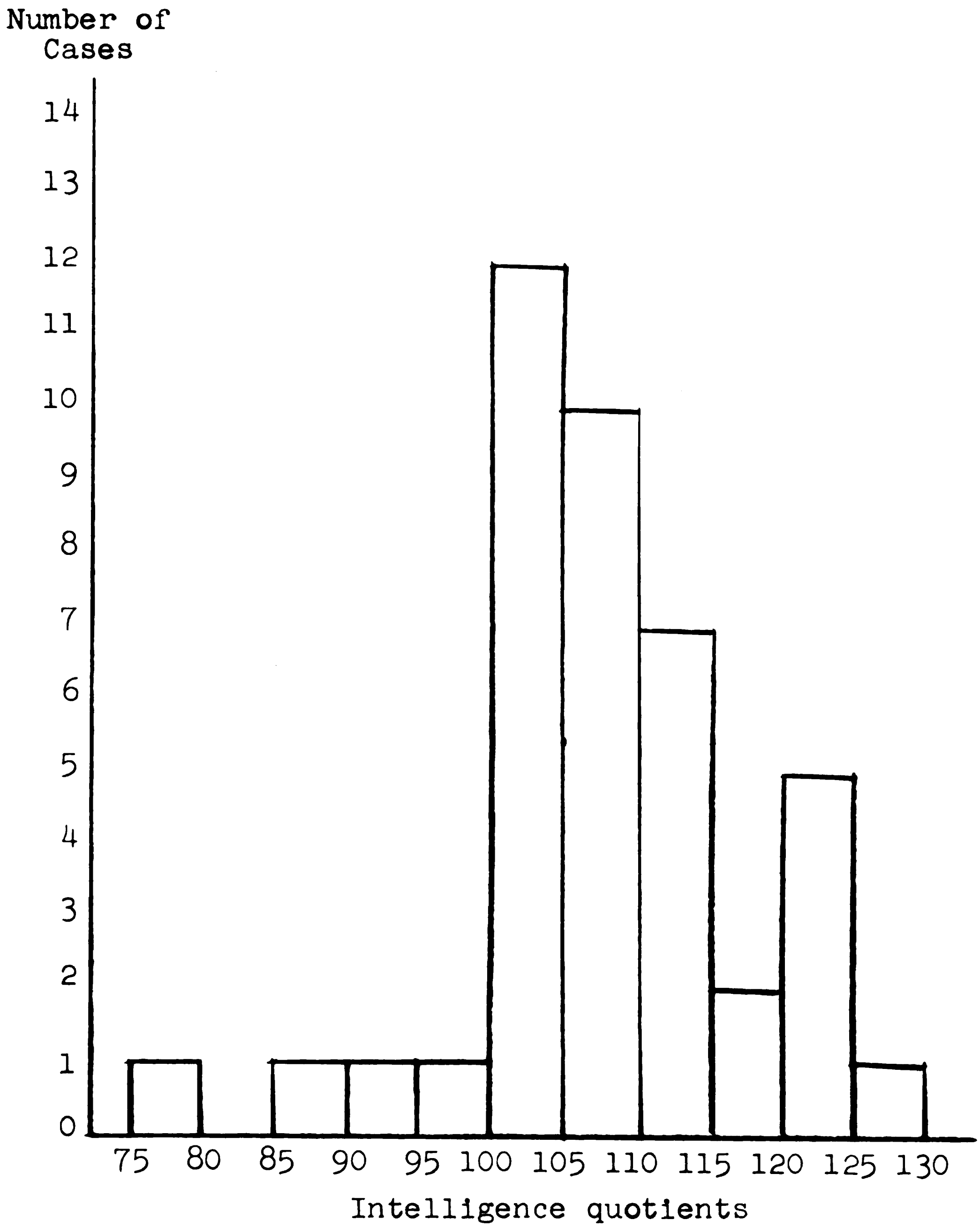


Figure 2. Distribution of Intelligence
Quotients Including Both Sexes

average I.Q. of 107 and the average I.Q. of the forty-four cases of this study (106.8) show very evident close agreement, which is significant at the five per cent level of confidence. Hollingshead would place the parents of the children in this study in his Class III category.

> Forty-two percent of the . . . . families in Class III own small businesses, farms, or are independent professionals. The other 58 percent derive their livelihood from wages and salaries.[114]

According to the 'Revised Scale for Rating Occupation' by Warner,[115] the occupations of the fathers of the children of this study place their families in Class IV. This class includes proprietors and managers of businesses valued at $2,000 to $5,000; factory foremen; and owners of electrical, plumbing, carpentery, and watch repair businesses.

Each of these classifications places the children in a mid or central position of social stratification.

Method

In order to study human growth relationships it is necessary that unequivalent units of measures be equated in some manner. The Courtis method, which is utilized

---

[114]A. B. Hollingshead, Elmtown's Youth (New York: John Wiley and Sons, Inc., 1949), p. 96.

[115]W. L. Warner, et al, Social Class in America (Chicago: Science Research Associates, Inc., 1949), pp. 140-142.

in this study, accomplishes this by converting all measures to equal units called 'isocrons.' The Courtis method, an adaptation of the Gompertz Function $y = ki^{r^t}$, reduces the cyclic pattern of growth to the mathematical formula $y = k\,[rt \pm i]$ in which y = achieved growth, k = maximum, r = rate, t = time, i = incipiency, and $[\;\;]$ = enclosure of isocronic values. A detailed explanation of this method is given in Courtis' manual, <u>Maturation Units and How to Use Them</u>.[116]

Original measures, for each case, were processed by the Courtis method to obtain an equation for two cycles of height and weight growth each. As a purpose of this study is to determine the accuracy with which the Courtis Method describes growth, the predicted scores were calculated as closely as possible to the actual measures. The average deviation of predicted measures from actual measures was calculated without consideration of sign.

All subsequent derived scores were determined from the above equations as follows:

1. b_1 -- substitute the isocronic value for 1 per cent (14.73) for 'y' in the individual equation, and solve for 't'. Omit 'k' from the equation.

2. t_1 and/or t_2 -- substitute the isocronic value for 99 per cent (76.00) for 'y' in the individual

---

[116] Obtainable from S. A. Courtis, 9110 Dwight Avenue, Detroit 14, Michigan.

equation of the cycle desired. Omit 'k' from the equation.

3. c_1 -- substitute the age of the beginning of the adolescent cycle, as found in (1) above, into the adolescent equation and solve for 'y'.

4. Per cent of pre-adolescent cycle attained at the beginning of the adolescent cycle as follows: $b_1 \div k_1 \times 100$.

5. Per cent of total maturity attained at the beginning of the adolescent cycle as follows: $b_1 \div k_3 \times 100$.

Correlations were obtained through use of the 'rank-difference' method, for which the formula is:

$$r = 1 - \frac{6(D)^2}{n(n^2 - 1)} .$$

CHAPTER IV

ANALYSIS OF THE DATA AND DISCUSSION OF RESULTS

Through the use of the Courtis method of describing growth, disparate measures become amenable to mathematical and graphical comparison. The reduction of seriatim measures into a formula with the constants; rate, maximum, and incipiency, makes possible detailed analysis of these commonly accepted, but seldom specifically differentiated, components of the growth cycle.

Height and weight growth was described with gratifying accuracy by the above method. The deviation of predicted measures from actual measures was in all cases within the two per cent limits specified by Courtis.[117] A list of these deviations may be found in Appendix H. The average of all boy's height deviations was .182 inches with a range of .094 through .256 inches. The average boy's weight deviations was .811 pounds with a range of .143 through 1.5 pounds. The average of the girl's height deviations was .2 inches with a range of .106 through .283 inches. The average of the girl's weight deviations was

---

[117] Courtis, _Maturation Units and How to Use Them_, _op. cit._, p. 129.

.885 with a range of .106 through 1.855 pounds. These deviations are all within the acceptance limits of the error of measurement established for the collection of anthropometric measurements by Dearborn and Rothney.[118]

Three cases were chosen by chance to demonstrate graphically the adequacy of the method employed in this study (Figures 3 through 8).

Even a cursory inspection of deviations of predicted scores from actual measured scores would reveal that height scores are more closely described by the Courtis method than are weight scores. Such results are only natural, as other studies have shown that monthly gains in weight are more variable than gains in height.[119,120] Some possible reasons for such weight variability are: (1) weight scores are easily and suddenly alterable by oral acquisition, or by anal elimination of liquid or solid substances, (2) weight has been found to fluctuate with

---

[118]Dearborn and Rothney, Predicting the Child's Development, op. cit., p. 83.

[119]Meinhard Robinow, "The Variability of Weight and Height Increments from Birth to Six Years," Child Development, June, 1942, Vol. 13, No. 2, pp. 159-164.

[120]C. E. Palmer, et al, "Anthropometric Studies of Individual Growth. II. Age, Weight, and Rate of Growth in Weight, Elementary School Children," Child Development, Vol. 8, No. 1.

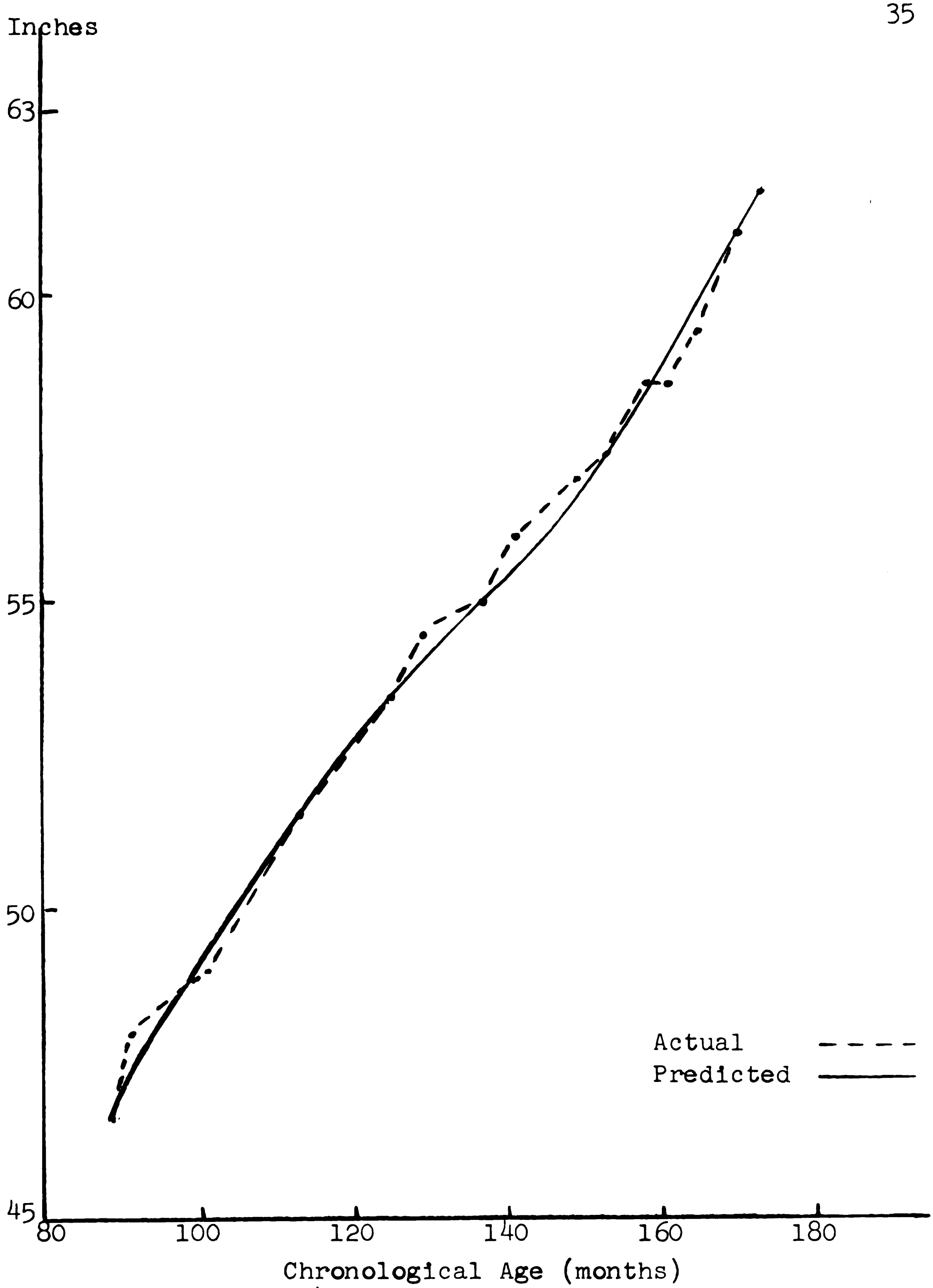


Figure 3. Case 83M Height

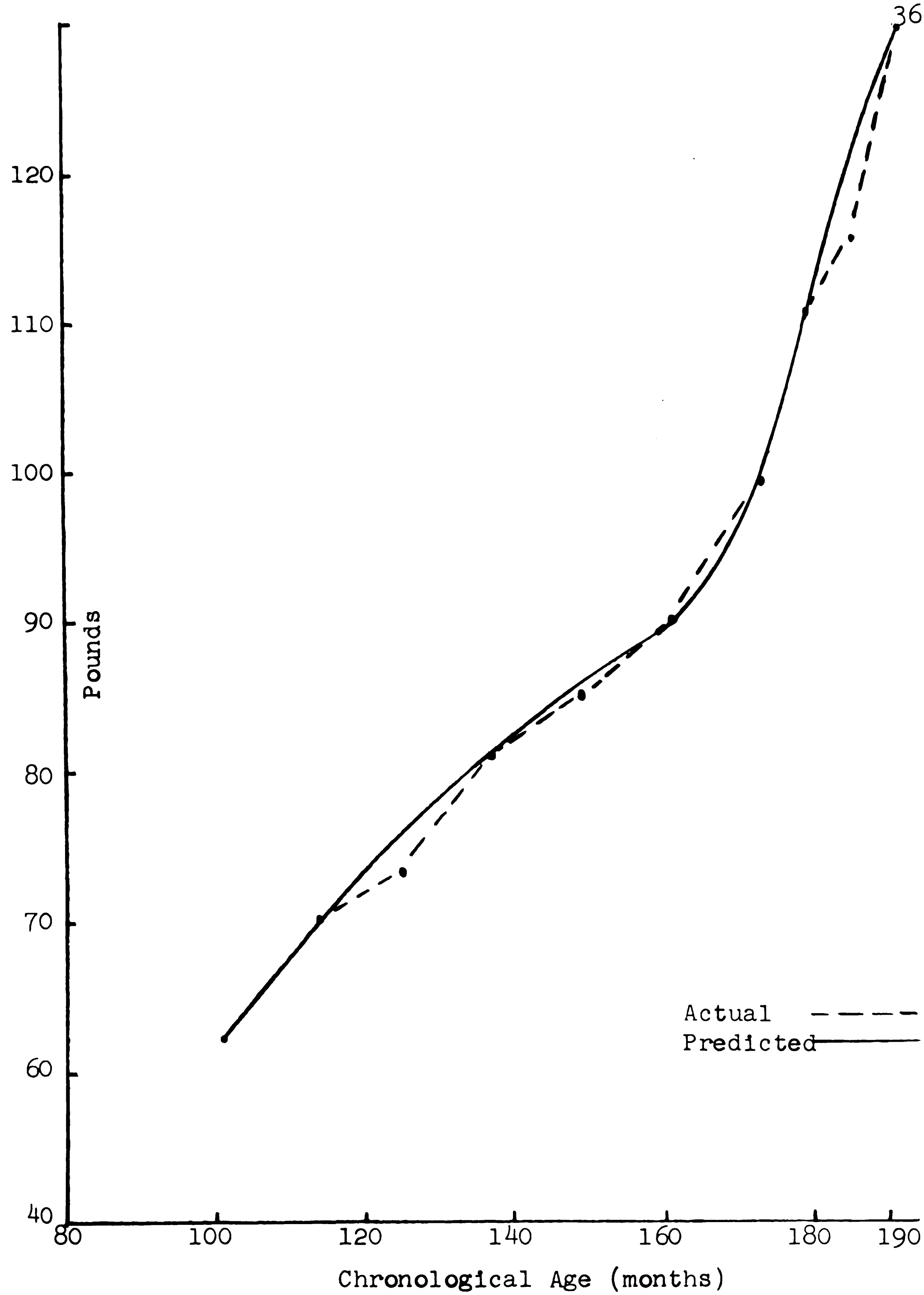


Figure 4. Case 83M Weight

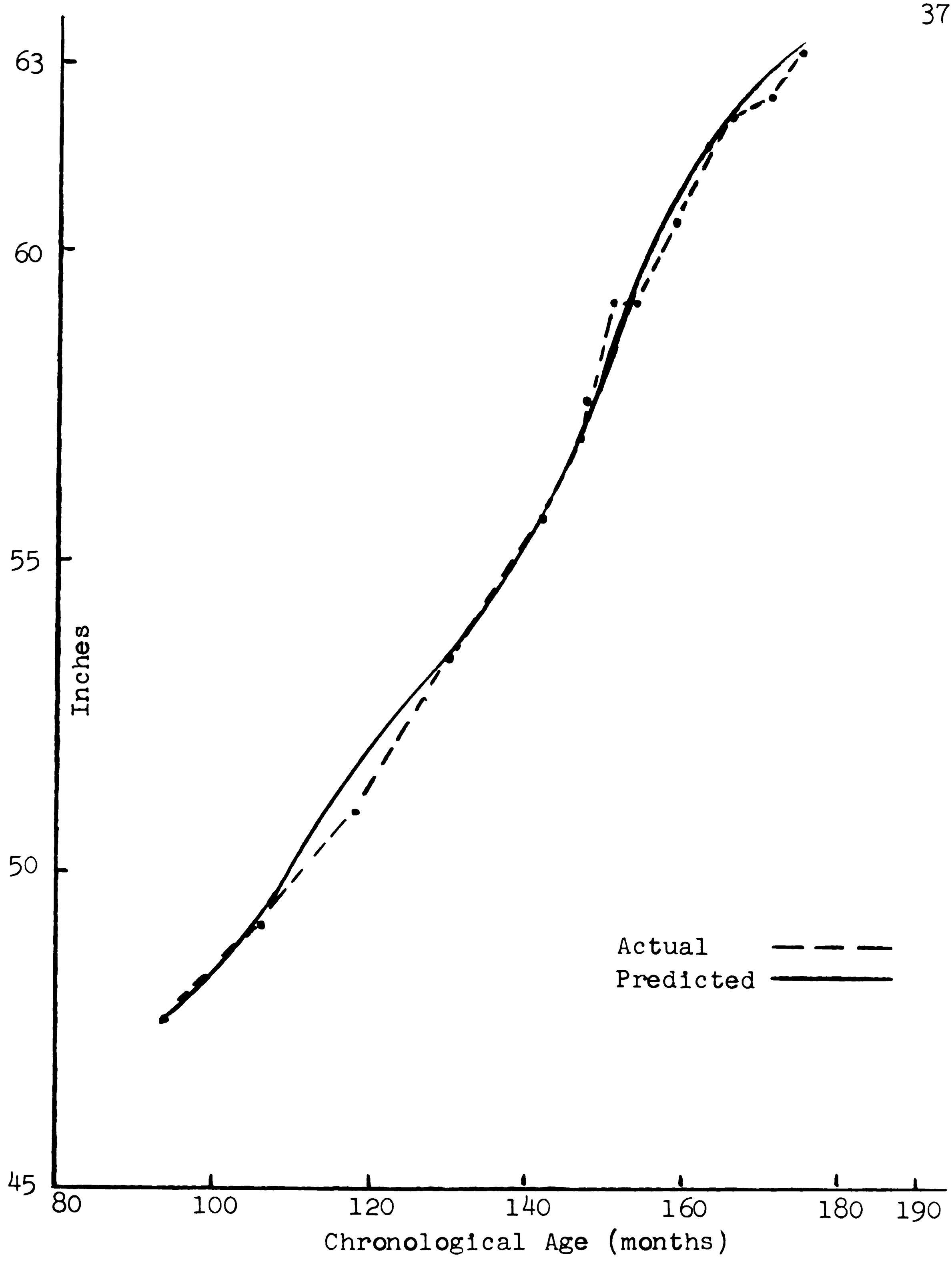


Figure 5. Case 118F Height

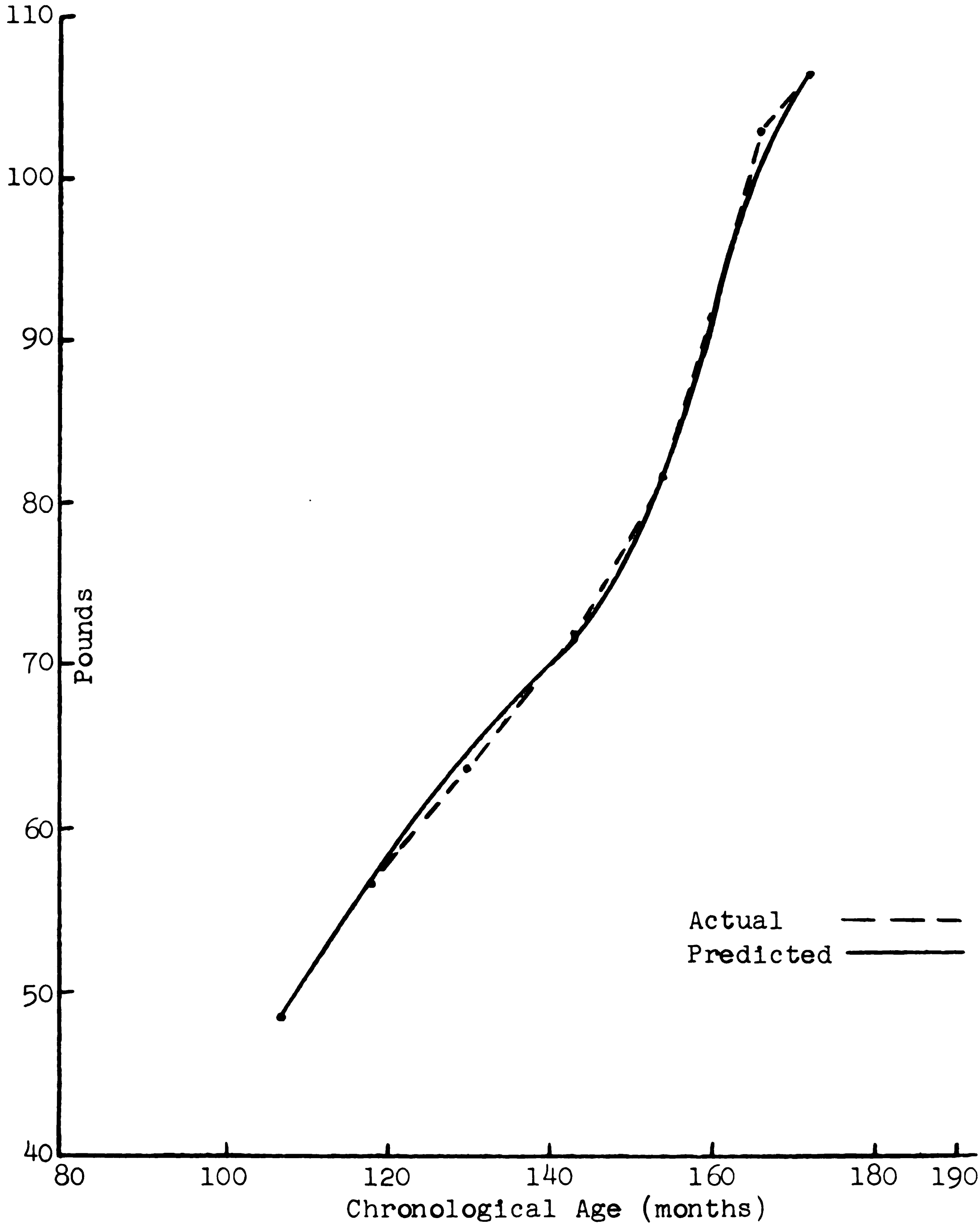


Figure 6. Case 118 F Weight

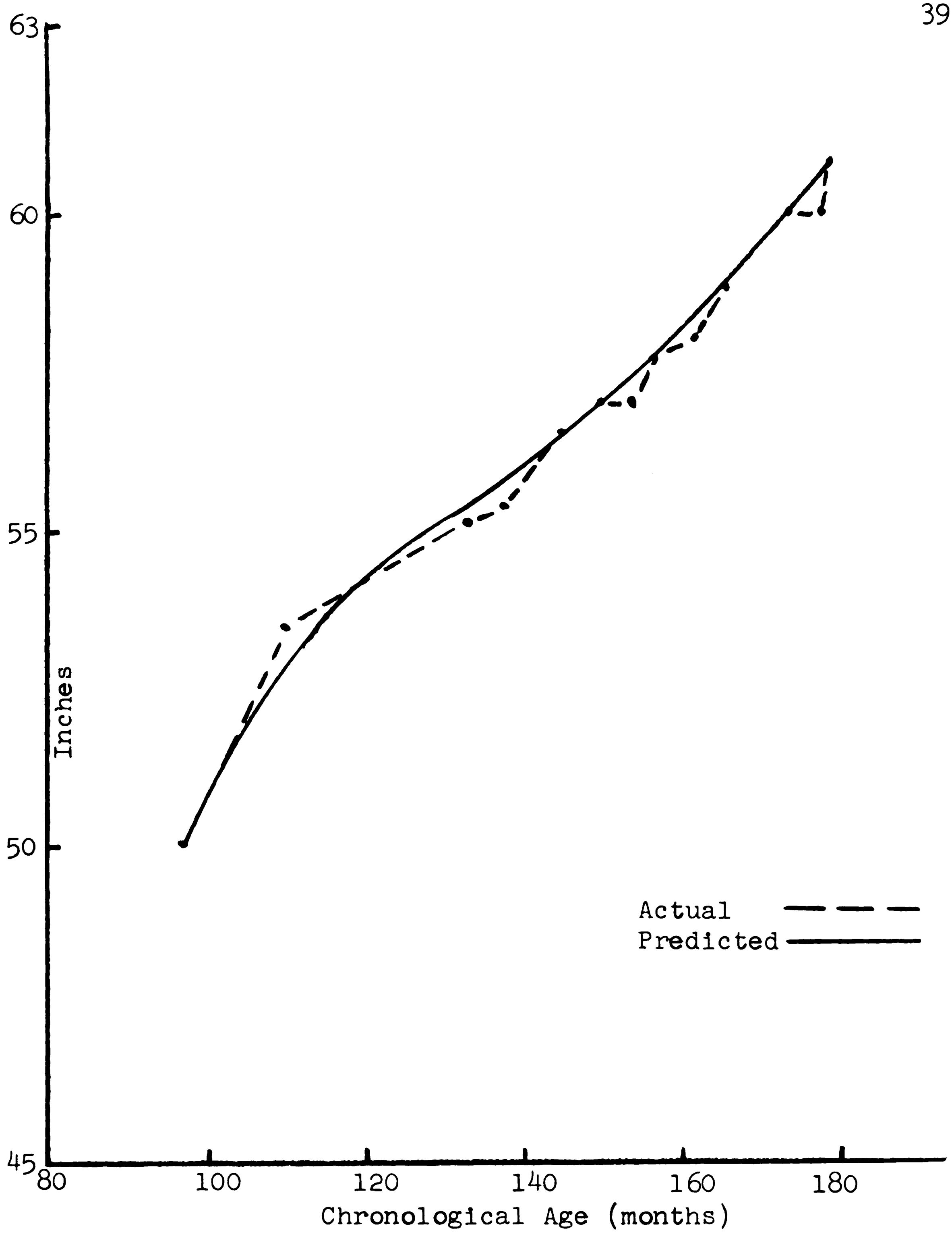


Figure 7. Case 176M Height

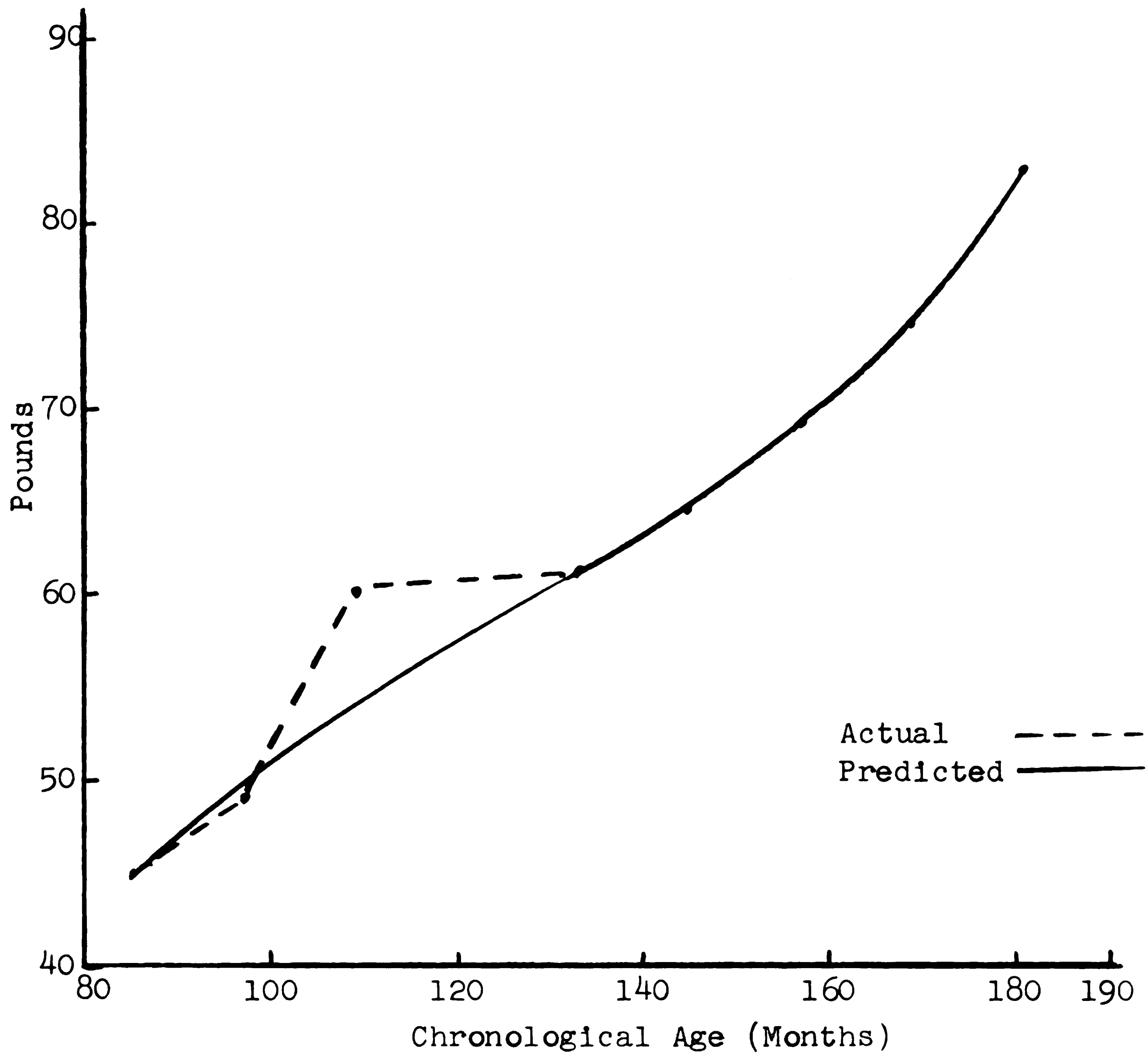


Figure 8. Case 176 M Weight

the season of the year[121,122,123] as does height. Even though height is relatively steady in its growth pattern, it is subject to variability due to compression of the spinal disks.[124] Then, too, both height and weight may show unreal variance because of errors of measurement.[125] Figures 9 and 10 show how height deviations cluster closely around zero, while weight deviations are more widely dispersed.

As the Courtis method has been shown to be accurate for describing height and weight growth, attention may be given to the use of this technique to derive correlations between various aspects of growth.

Correlations found by using the rates of height and weight equations, were generally low and inconclusive

---

[121]A. B. Fitt, "Seasonal Influence on Growth Function and Inheritance," New Zeland Council for Educational Research (New Zeland: Whitcombe and Tombs, Ltd., 1941), pp. 1-182.

[122]C. E. Turner and Alfred Nordstrom, "Extent and Seasonal Variations of Intermittency in Growth," American Journal of Public Health, 1938, Vol. 28, pp. 499-505.

[123]E. A. Reynolds and L. W. Sontag, "Seasonal Variations in Weight, Height, and Appearance of Ossification Centers," The Journal of Pediatrics, 1944, Vol. 24, pp. 524-535.

[124]Krogman, "A Handbook of the Measurement and Interpretation of Height and Weight in the Growing Child," op. cit., p. 19.

[125]H. M. Walker and J. Lev, Statistical Inference (New York: Henry Holt and Company, 1953), pp. 293-295.

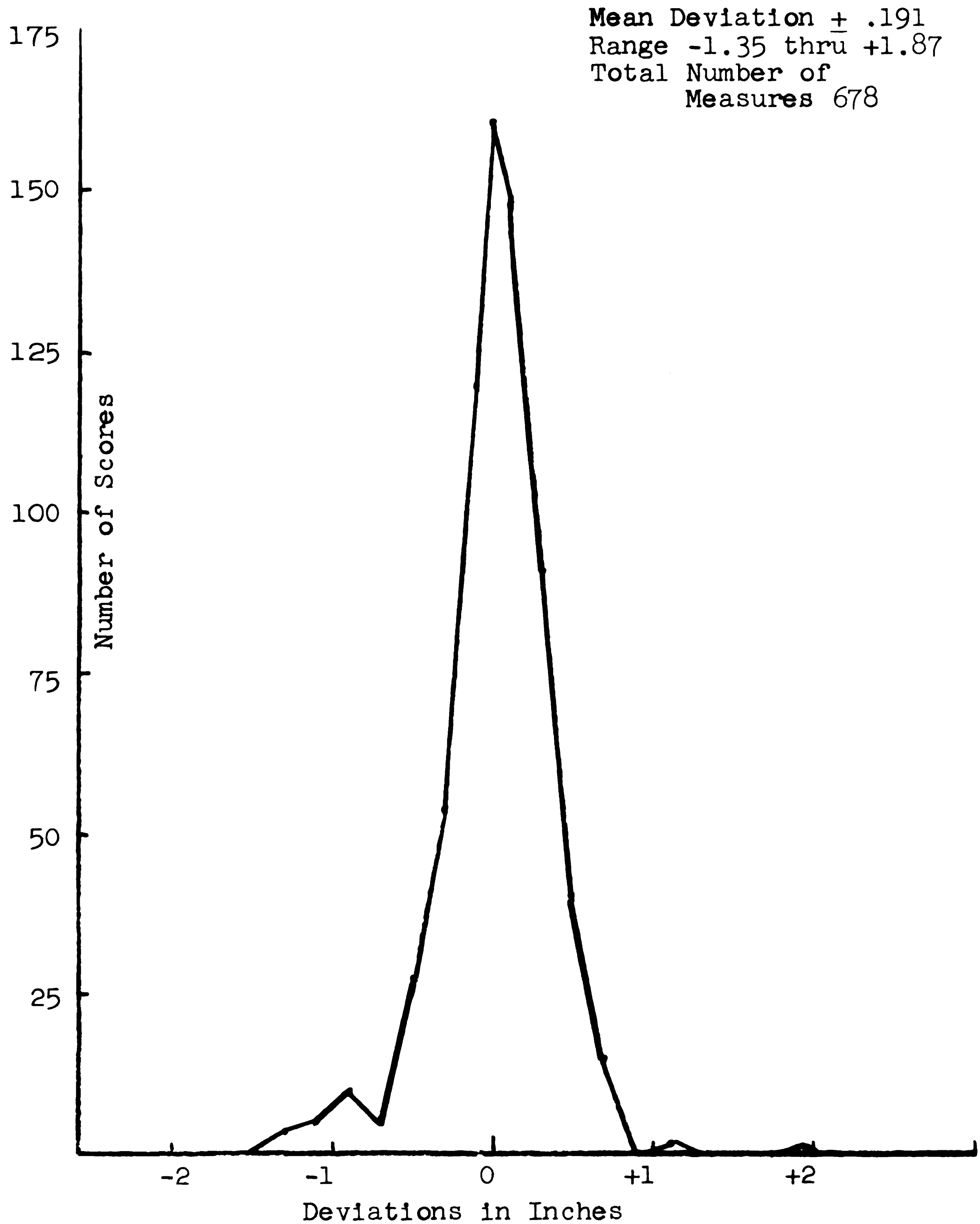


Figure 9. Distribution of Height Predicted Scores from Actual Measures

Mean Deviation $\pm$ .848
Range -8.95 thru +6.99
Total Number of Measures 379

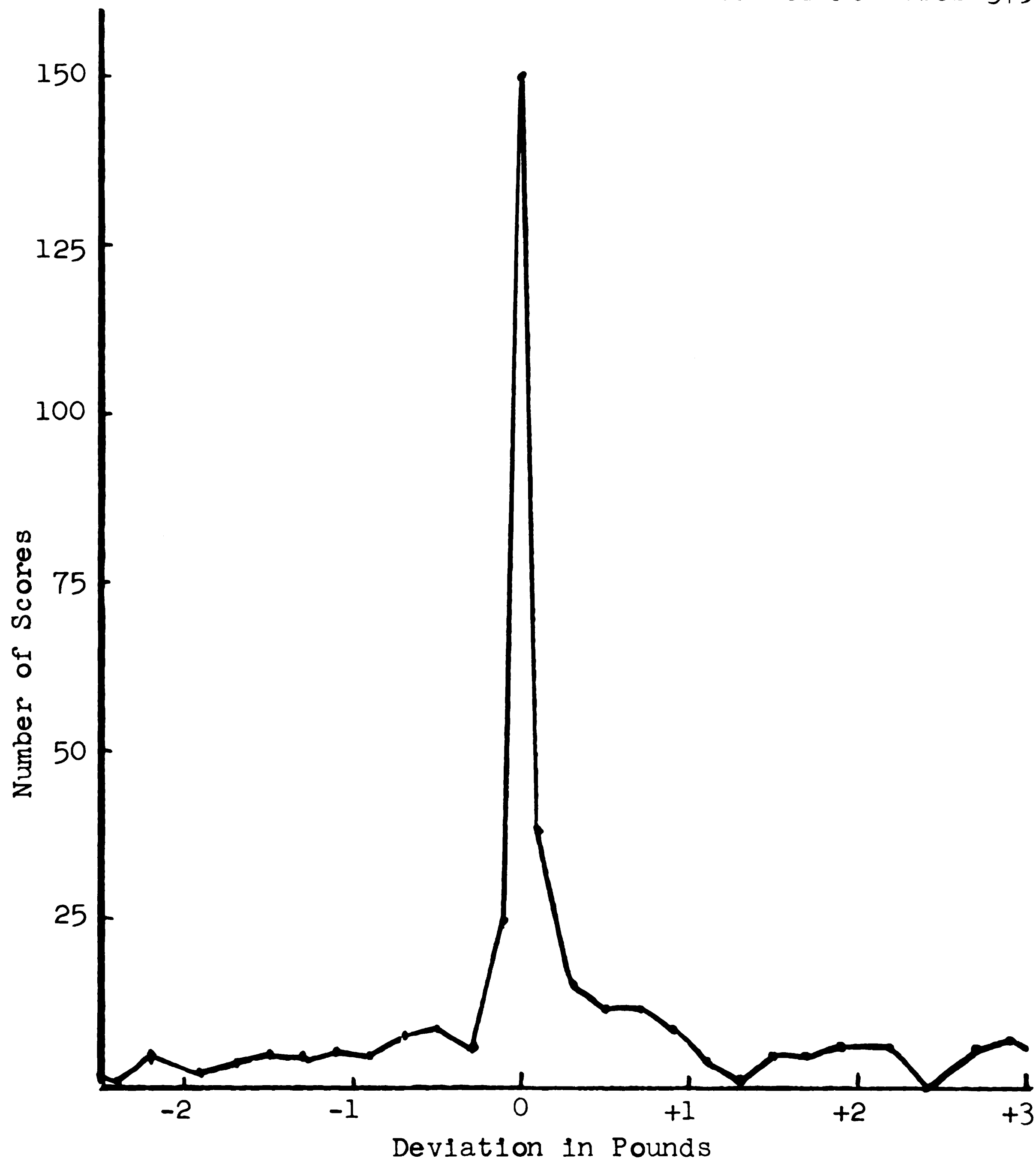


Figure 10. Distribution of Weight Predicted Scores from Actual Measures

(Table I). When r_1 height was correlated with the corresponding r_1 weight, the boys' +.53 was significant at the five per cent level. The girls' +.06, however, was not. Correlations obtained between the height r_2 and weight r_2 resulted in much the same values. The boys' correlation of +.44 was again significant, while the girls' +.06 once again was not.

Height r_1 when correlated with height r_2 gave a correlation of +.07 for the boys, and +.29 for the girls. Neither figure was significant at the five per cent level. Weight r_1 when correlated with weight r_2 produced wide differences. The boys' correlation was -.14, while the girls' correlation of +.41 was positively significant at the five per cent level.

Therefore, even though some of the correlations were significant at the five per cent level of confidence, the rate correlations were not large enough to be used for prediction. However, as all but one correlation was positive, there is a tendency for all rates to maintain their position as to magnitude. In other words, faster growers in height tend to be faster in weight growth, and faster growers in the pre-adolescent cycle tend to be the faster growers in the adolescent cycle.

The correlations obtained from predicted maxima show an interesting pattern of growth. Four negative correlations stand out from the host of positive

TABLE I

RATE CORRELATIONS

	Boys	Girls
r_1 height with r_1 weight	+.53 (sig)	+.06
r_2 height with r_2 weight	+.44 (sig)	+.06
r_1 height with r_2 height	+.07	+.29
r_1 weight with r_2 weight	-.14	+.41(sig)

correlations, (Table II). These four--two for boys and two for girls--are obtained by comparing the maxima of a growth of the pre-adolescent cycle, with the maxima of the same growth of the adolescent cycle. These negative correlations are not large enough for predictive use. But they do show a tendency, on the part of those who are growing to high pre-adolescent maxima, to grow to smaller maxima in the adolescent cycle. Vice versa, those growing toward lower pre-adolescent maxima tend to grow to larger adolescent maxima.

Herein lies a possible explanation of the cause of the lower-than-perfect positive correlations obtained when pre-adolescent (k_1) and adolescent (k_2) maxima are compared with final or total (k_3) maturities. As the negative correlations are not large enough for predictive use, this may be an inclination toward moderation of the extremes.

TABLE II

MAXIMA CORRELATIONS

	Boys	Girls
k_1 height with k_1 weight	+.35 (sig)	+.30
k_2 height with k_2 weight	+.59 (sig)	+.23
k_3 height with k_3 weight	+.10	+.02
k_1 height with k_2 height	-.38 (sig)	-.41 (sig)
k_1 height with k_3 height	+.70 (sig)	+.67 (sig)
k_2 height with k_3 height	+.38 (sig)	+.41 (sig)
k_1 weight with k_2 weight	-.14	-.27
k_1 weight with k_3 weight	+.47 (sig)	+.73 (sig)
k_2 weight with k_3 weight	+.62 (sig)	+.47 (sig)

The very low correlations obtained when comparing total maturities (k_3) of height and weight may be a reflection of differences in body build. If a perfect correlation was obtained for this, it would mean that people of equivalent heights would also be of equivalent weight. The correlations obtained in this study (+.10 boys, +.02 girls) would suggest that a certain height does not presuppose a certain weight. This lends support to the belief that each person must be studied as an individual rather than forcing them to fit a norm.[126]

---

[126]Millard, _Child Growth and Development_, _op. cit._, p. 31.

Correlations derived from ages attained at one per cent of adolescent growth, 99 per cent of pre-adolescent growth, and 99 per cent of adolescent growth (Table III) showed much the same results as were obtained through comparison of rates (Table I). Once again the correlations are positive--except for boys' t_1 weight with t_2 weight--but too low for predictive purposes. Correlations between height and weight at one per cent of the adolescent cycle (+.41 boys, +.59 girls) were significant at the five per cent level for both boys and girls.

TABLE III

CORRELATIONS OF AGES AT SPECIFIC PER CENTS OF DEVELOPMENT

	Boys	Girls
b_1 height with b_1 weight	+.41 (sig)	+.59 (sig)
t_1 height with t_1 weight	+.56 (sig)	+.14
t_2 height with t_2 weight	+.42 (sig)	+.23
t_1 height with t_2 height	+.11	+.36
t_1 weight with t_2 weight	-.13	+.28

Positively significant correlations resulted when boys' height and weight ages at 99 per cent of the pre-adolescent cycle were compared (+.56 and +.42 respectively).

The girls correlations obtained in a similar fashion were positive, but not significant (+.14 and +.23 respectively).

Correlations of +.36 and +.28 which resulted from comparing girls' height ages at 99 per cent of the pre-adolescent and adolescent cycles and weight ages at the same percentages were not significant. The boys' correlations of +.11 and -.13 respectively were also not significant.

A tendency for both boys' and girls' height ages to increase in proportion to their weight ages is shown by these correlations. Such results may be expected due to positive correlations obtained when rates of height were compared with rates of weight.

Correlations found between height or weight values at one per cent of the adolescent cycle and various maxima (Table IV) bear out the previous interpretations of this study.

The correlations +.38 for boys and +.59 for girls found by comparing height values (inches) at one per cent of the adolescent cycle (c_1) with weight values (pounds) at a similar percentage were both significant at the five per cent level. Both figures were too small for predictive use. Thus, height and weight values at one per cent of the adolescent cycle show an inclination to be of equal rankings.

TABLE IV

CORRELATIONS OF VALUES ATTAINED

	Boys	Girls
c_1 height with c_1 weight	+.38 (sig)	+.59 (sig)
c_1 height with k_2 height	-.50 (sig)	+.01
c_1 weight with k_2 weight	-.21	-.51 (sig)
c_1 height with k_3 height	-.12	+.06
c_1 weight with k_3 weight	-.22	-.22

Correlations between the same growth factors, i. e. height with height, each using one per cent of the adolescent cycle, produced negative results in all but two cases. These negative correlations would further support the implication that growth tends to reverse its magnitude during the adolescent cycle of growth. Even though some of the correlations are significant at the five per cent level of confidence, they are too low for predictive purposes.

The negative correlations obtained here and in Table II, when combined with the positive correlations between rates of the pre-adolescent and adolescent cycles, would suggest that those children with high maxima and high rates for the pre-adolescent cycle, have high rates and lower maxima for the adolescent cycle. This suggests a pattern of growth that is short in time, but fast as to growth gains, during the adolescent cycle. The converse of the above pattern would be that those individuals with low maxima and low rates in the pre-adolescent cycle would tend to have relatively higher maxima and low rates in the adolescent cycle. This adolescent cycle would be one of small gains or increments, coupled with a long period of growth.

Table V shows cases taken from this study which illustrate the above patterns.

TABLE V

REVERSALS OF HEIGHT GROWTH PATTERNS

Case	Average	163M	129M
Preadolescent Maximum	62.6	68.0	59.0
Adolescent Maximum	7.8	7.0	10.0
Preadolescent Rate	.23237	.27824	.16813
Adolescent Rate	.72467	1.02429	.63824
Length of Adol. Cycle	84.55	59.82	96.00

Percentages of development convert different values to a single scale. Thus, it is possible to compare these different values, within the same cycles and between cycles. If growth relationships do exist, such relationships should appear when values are converted and compared on the single percentage scale. Table VI partially confirms the existence of such relationships.

TABLE VI

CORRELATIONS OF PERCENTAGES OF GROWTH AT BEGINNING OF ADOLESCENT CYCLE

	Boys	Girls
d_1 height with d_1 weight	+.39 (sig)	+.07
d_2 height with d_2 weight	+.47 (sig)	-.03
d_1 height with d_2 height	+.51 (sig)	+.59 (sig)
d_1 weight with d_2 weight	+.61 (sig)	+.46 (sig)

Percentage correlations were positive and significant at the five per cent level, except for two figures. These two were approximately zero (+.07 and -.03). The remaining correlations (d_1 and d_2) suggest the inclination for the percentages to maintain their relative positions in height and weight, and between height and weight at the time the adolescent cycle begins. However, the coefficients of correlation are not large enough to be used for prediction.

The Courtis method, which made possible correlative proceedures with speed of growth, timing of growth, and starting and ending points in cycles, did not produce definite proof of relationships. However, it did indicate some tendencies which may become more sharply defined upon further study.

Correlative procedures were used to find the existence and strength of relationships at specific points of the growth cycle. For a less precise, yet more encompassing consideration of growth, curves of constants were graphed from scores derived from the average case (see Appendices D--G). To show how these curves of this study compared with other curves, the curves of constants were plotted with height and weight age norms established by C. V. Millard.[127] The age norms, were calculated by cross-sectional methods on data supplied by the United States Department of Health, Education, and Welfare. Figures 11 and 12 portrayed much the same patterns. Boys height and weight curves of constants started lower than the age norms, slightly exceeded, dropped below at the beginning of the adolescent cycle once again, exceeded once more, and finally dropped below. The noticeably important difference in the comparison of the girls curves was that the curves of constants ended above that of the age norms.

The effect of cross-sectional averaging on the slope of the curves was well illustrated by Figures 11 and 12. Normatively cross-sectional curves were more gentle and

---

[127]C. V. Millard and J. W. M. Rothney, The Elementary School Child: A Book of Cases (New York: The Dryden Press, 1957), pp.638-645.

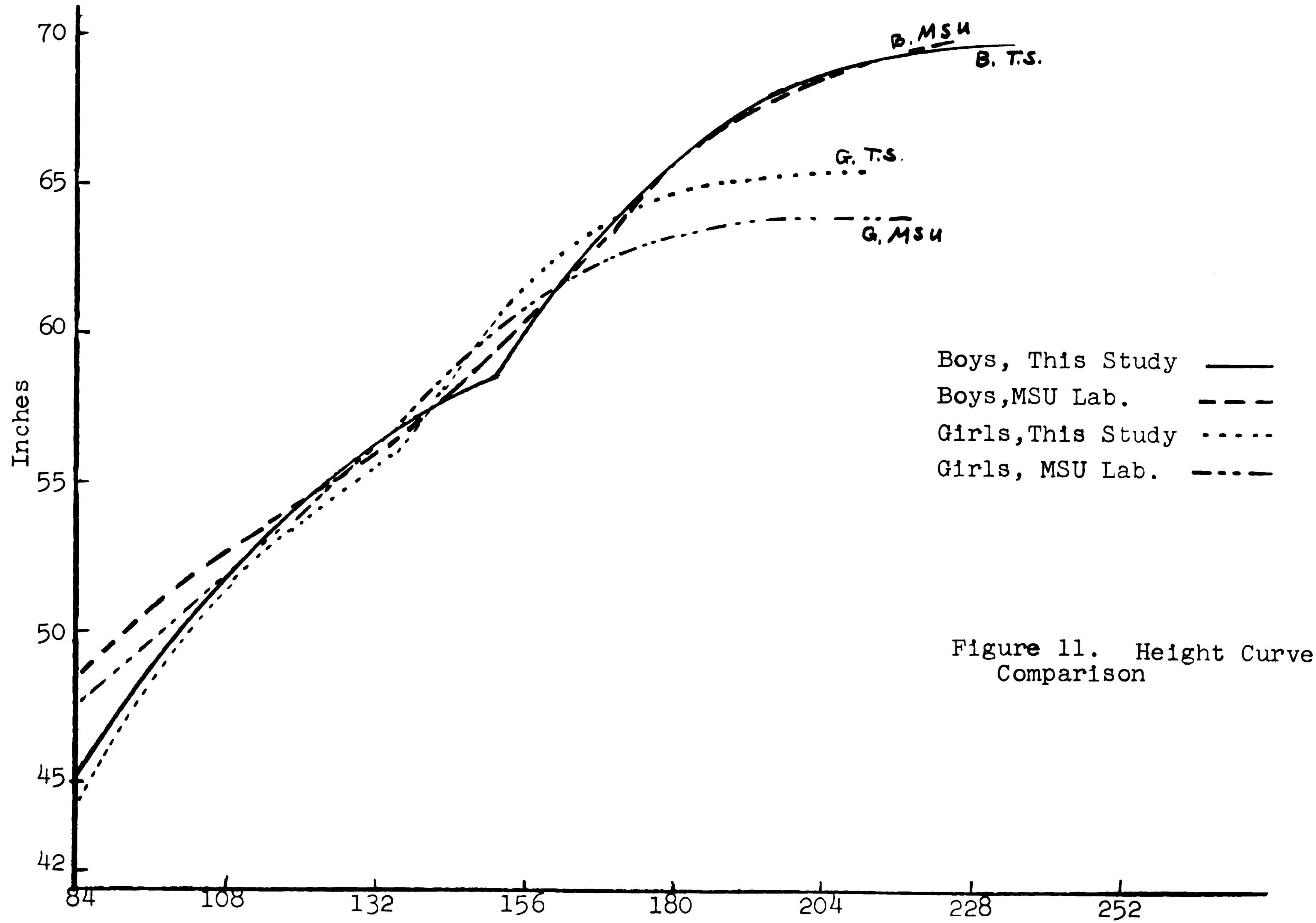


Figure 11. Height Curve Comparison

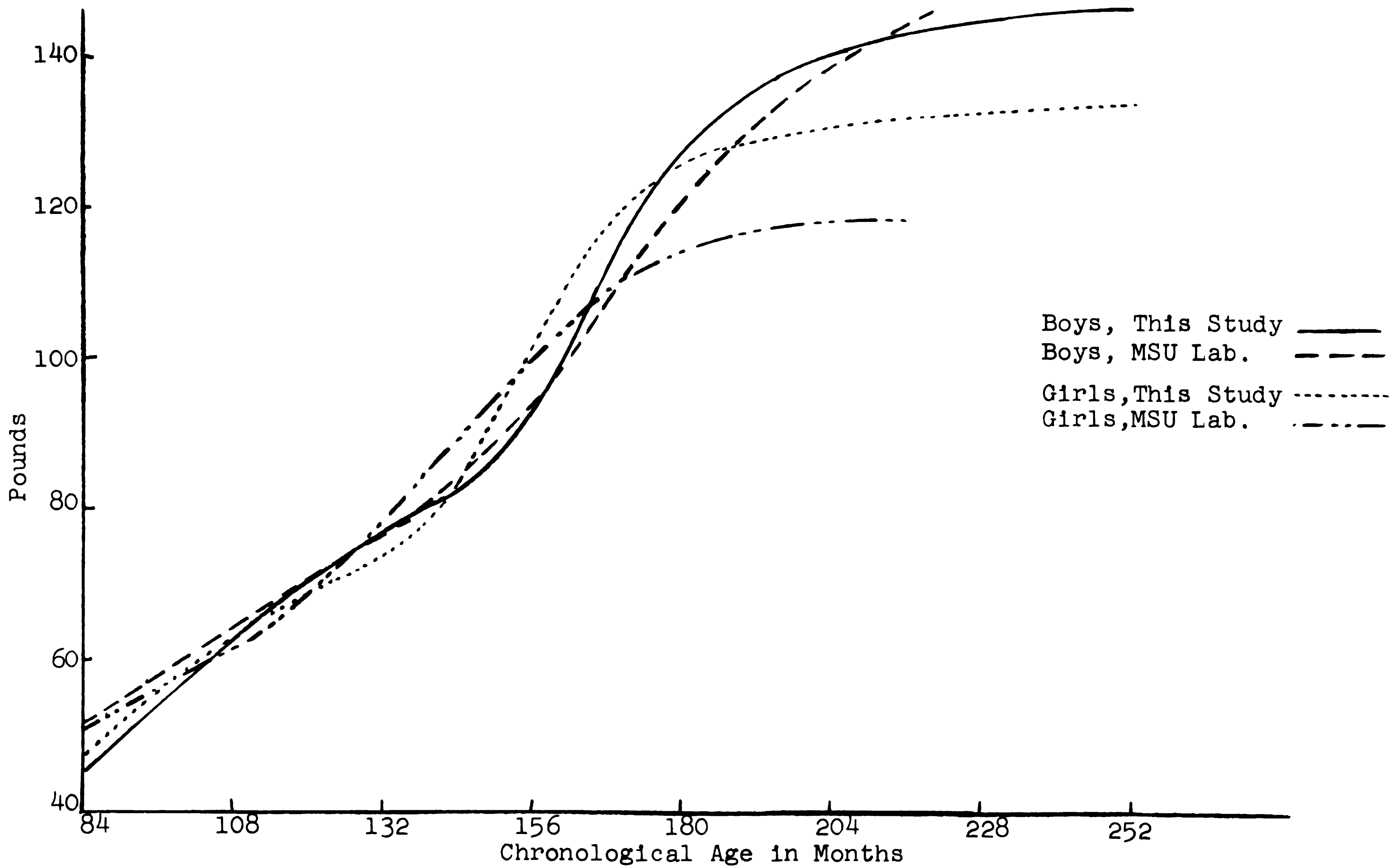


Figure 12. Weight Curve Comparison

flat, while curves of constants were more prominent and showed more definitely discernable cyclic starts.

A comparison of the curves of constants of the cases in this study in like factors of growth (Figures 13 and 14) revealed (1) that boys and girls growth is quite equivalent until eleven years of age, at about which time the girls start their adolescent growth, (2) that girls start and finish their adolescent height and weight cycles before the boys, (3) the girls cycles exceed those of the boys from approximately twelve years to fourteen years of age, and (4) the boys finally reach superiority in both factors of growth between fourteen and fifteen years of age. Many books mention this disparity in the growth of the sexes.[128]

Still another way of examining the over-all design of growth was utilized. Height and weight values were converted into percentages of development, by dividing each derived score by its total maturity value. The resulting percentages of total maturity, when graphed, described the curves shown in Figures 15 and 16. As was readily seen, there was no crossing of curves in these two figures. Girls' height and weight development were continually ahead of that of the boys. The girls' adolescent height cycle began at 83.4 per cent of total development,

---

[128] Helen Thompson, Child Psychology, Leonard Charmichael, ed., (New York: John Wiley and Sons, Inc., 1946), p. 270.

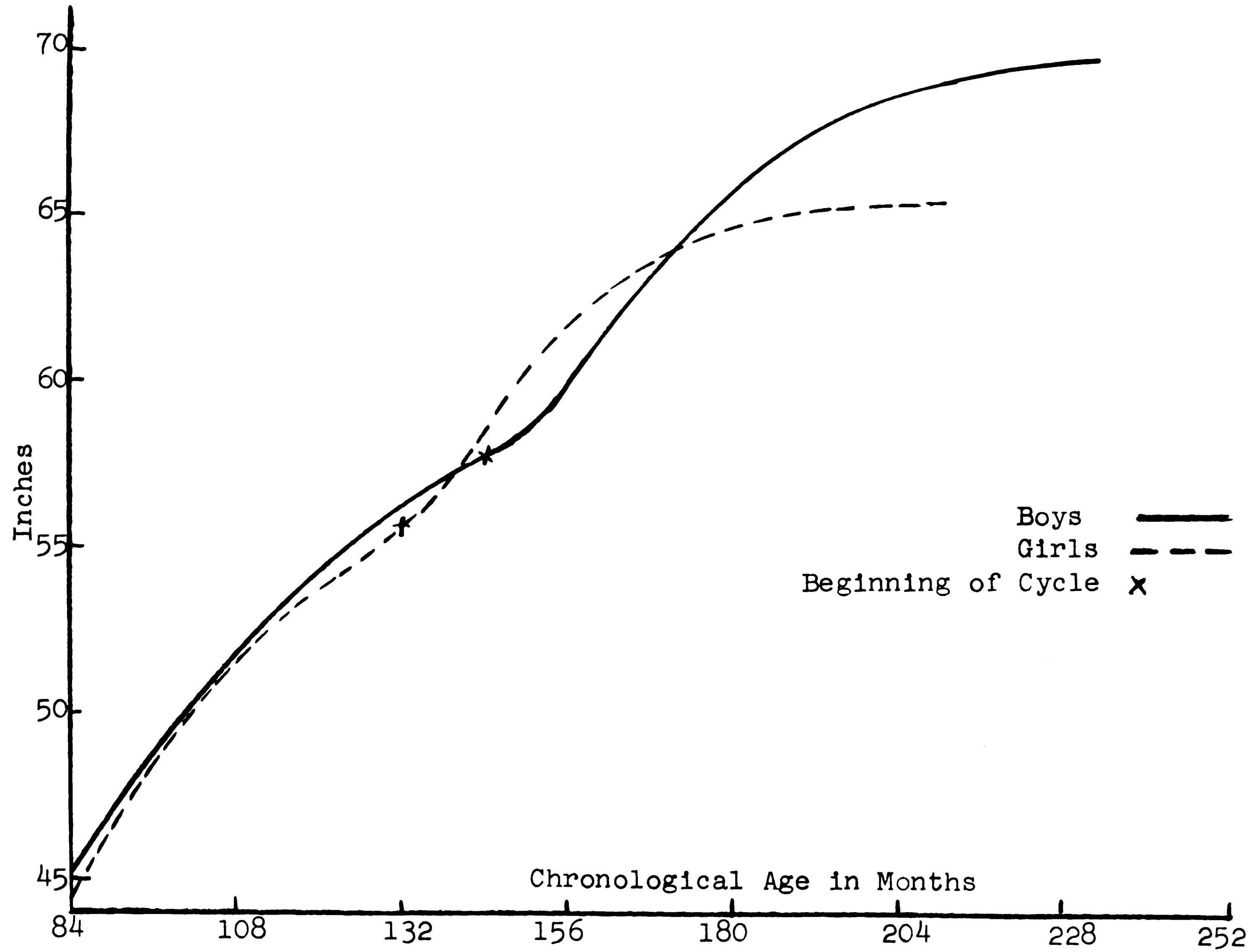


Figure 13. Curves of Constants--Height

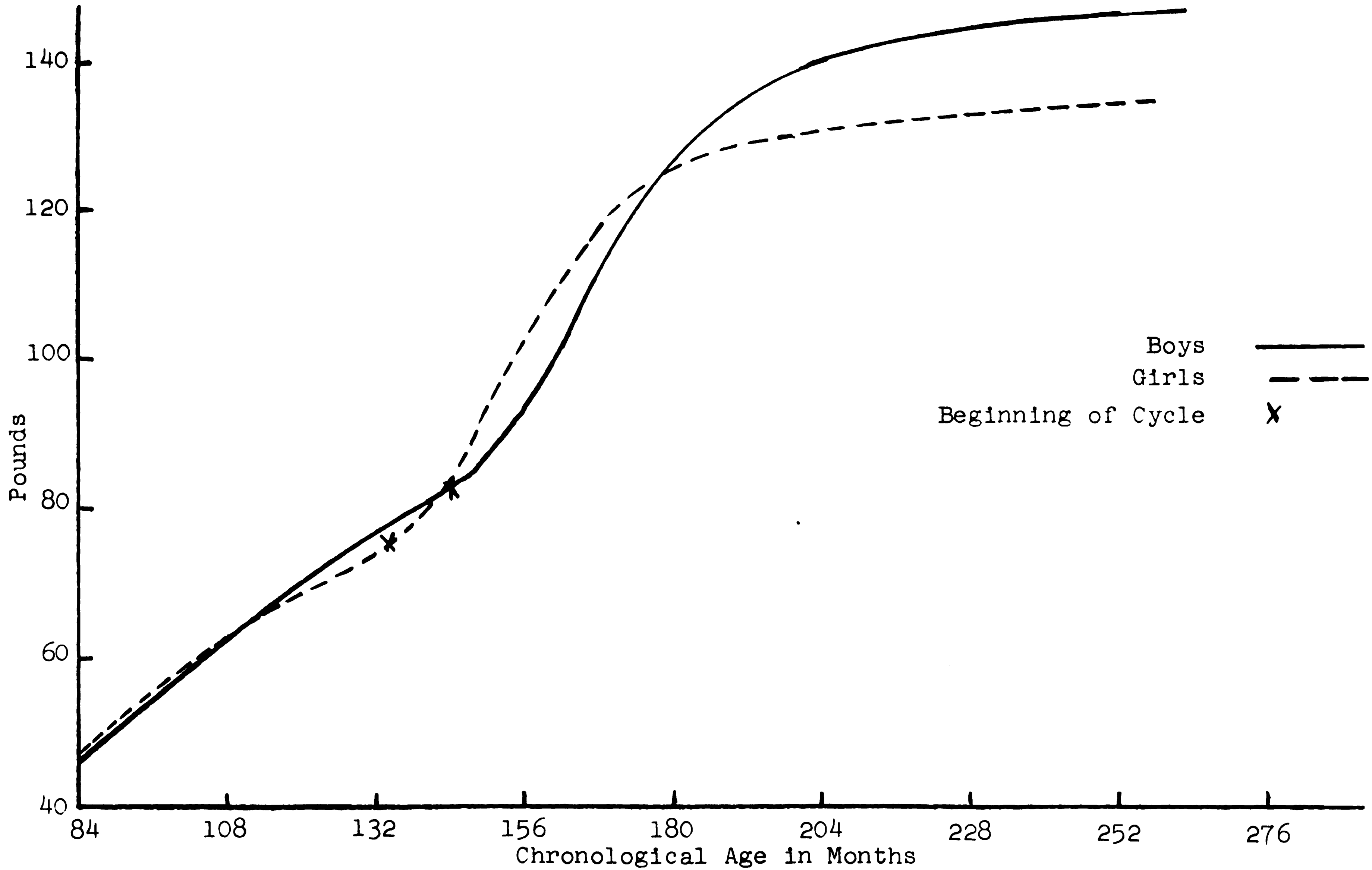


Figure 14. Curves of Constants--Weight

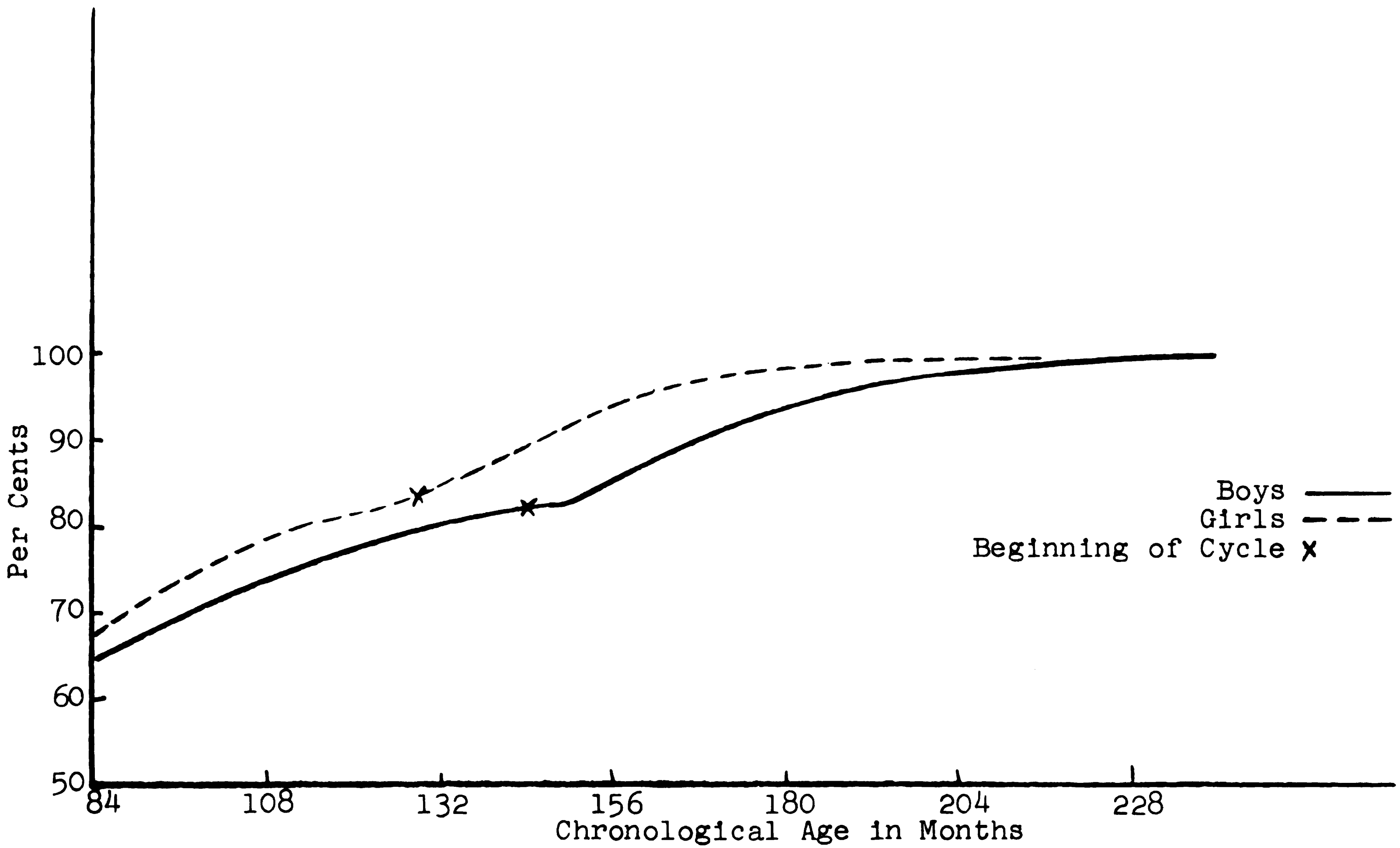


Figure 15. Curves of Total Maturity--Height Percentages

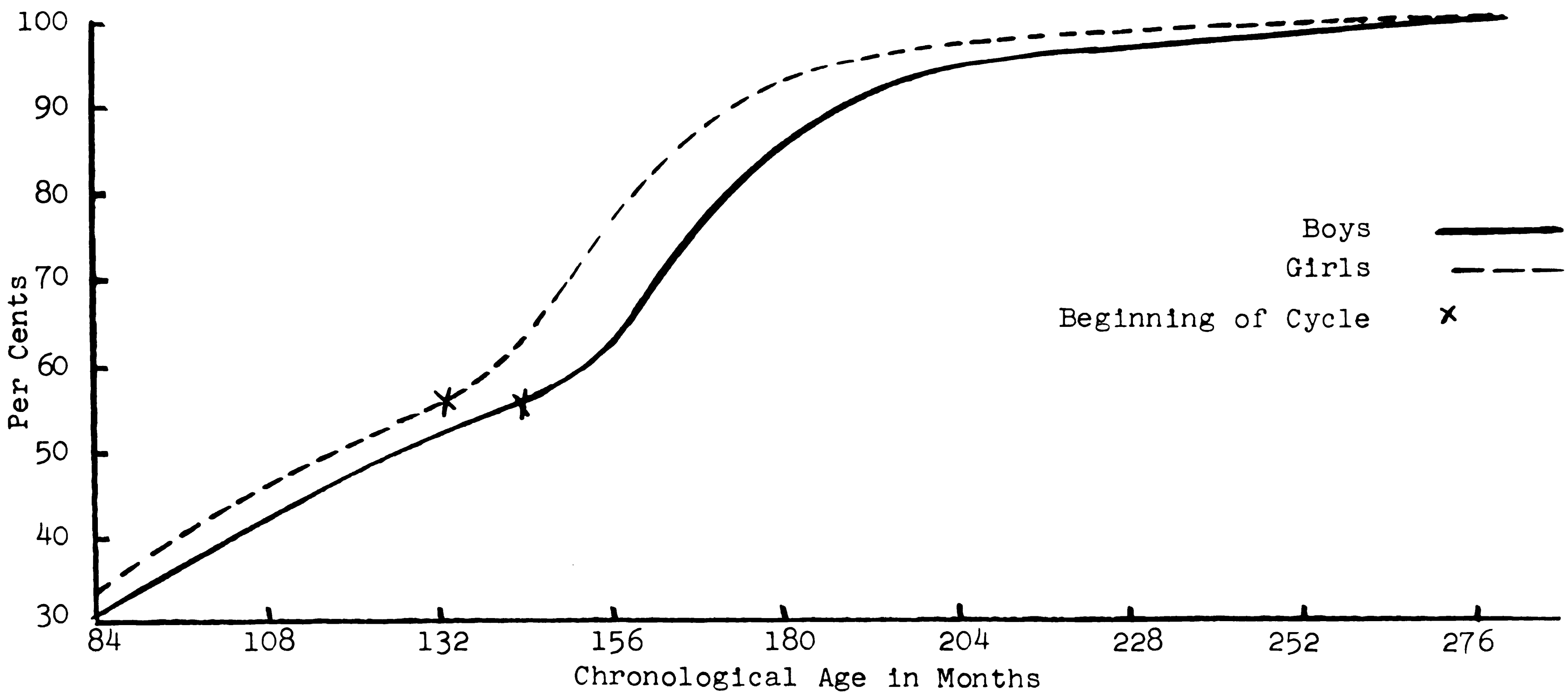


Figure 16. Curves of Total Maturity--Weight Percentages

and the boys' corresponding starting point was 82.2 per cent of total development. Boys and girls adolescent weight percentages at the beginning of the adolescent cycle were even closer at 55.5 per cent for the boys and 55.9 per cent for the girls. The above figures showed a close relationship between the percentage of development at which both sexes started their height and weight development.

When height and weight percentages of total maturity at the beginning of the adolescent cycle, were graphed according to sex (Figures 17 and 18), another relationship was discernible. The starting times of the boys' height and weight cycles were very nearly the same. Boys' adolescent height began at 144 months, and their weight cycle began at 145.5 months. A difference of only 1.5 months.

The difference between starting times for the girls was greater as their adolescent height cycle began at 128 months, while their adolescent weight cycle began at 135 months.

Use of the Courtis method to view growth over a long period of time revealed the advancement of girls' growth timing over that of the boys and the similarity of adolescent starting per cents and starting times within each sex. Such close timing within both sexes leads one to conjecture about the possibility of simultaneous starting times.

It is possible for two sets of scores, which are very closely grouped about their means, to produce no, or

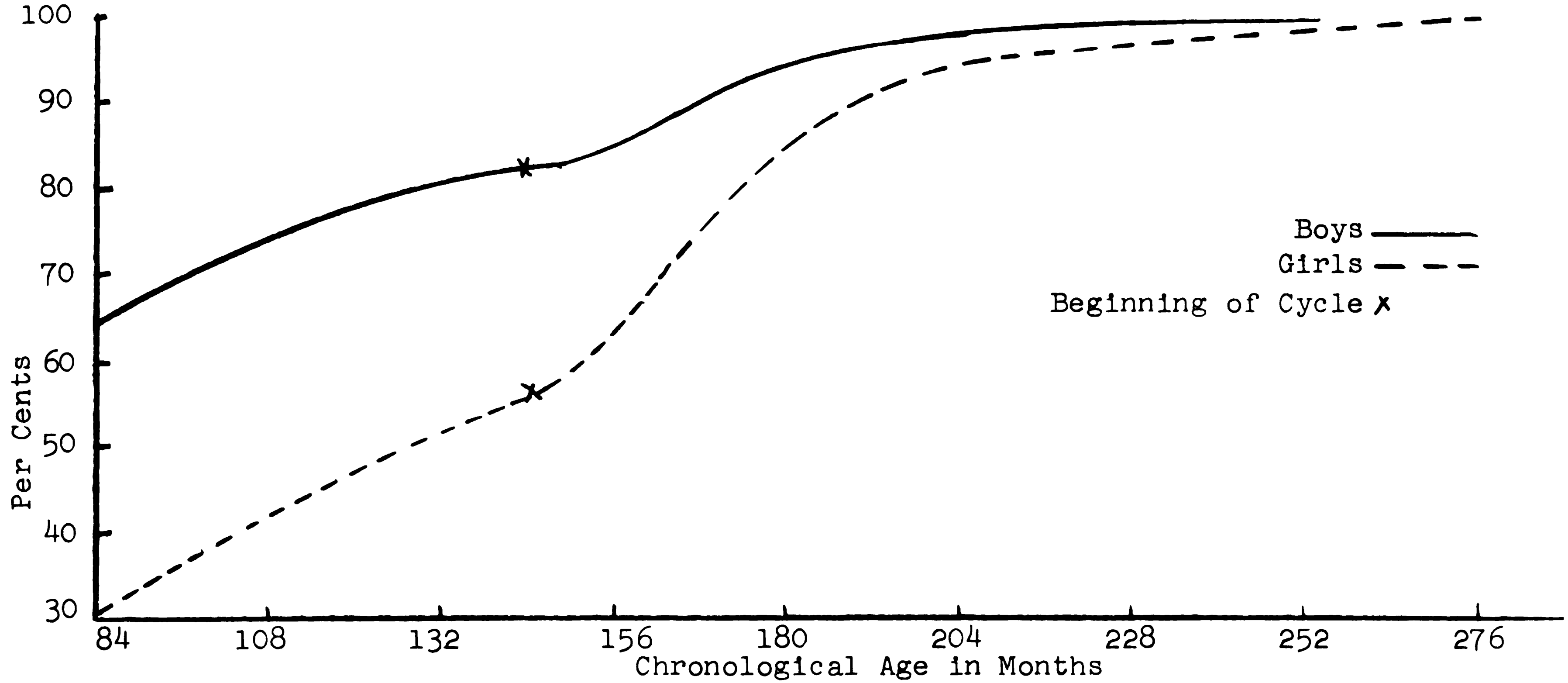


Figure 17. Curves of Total Maturity--Boys' Percentages

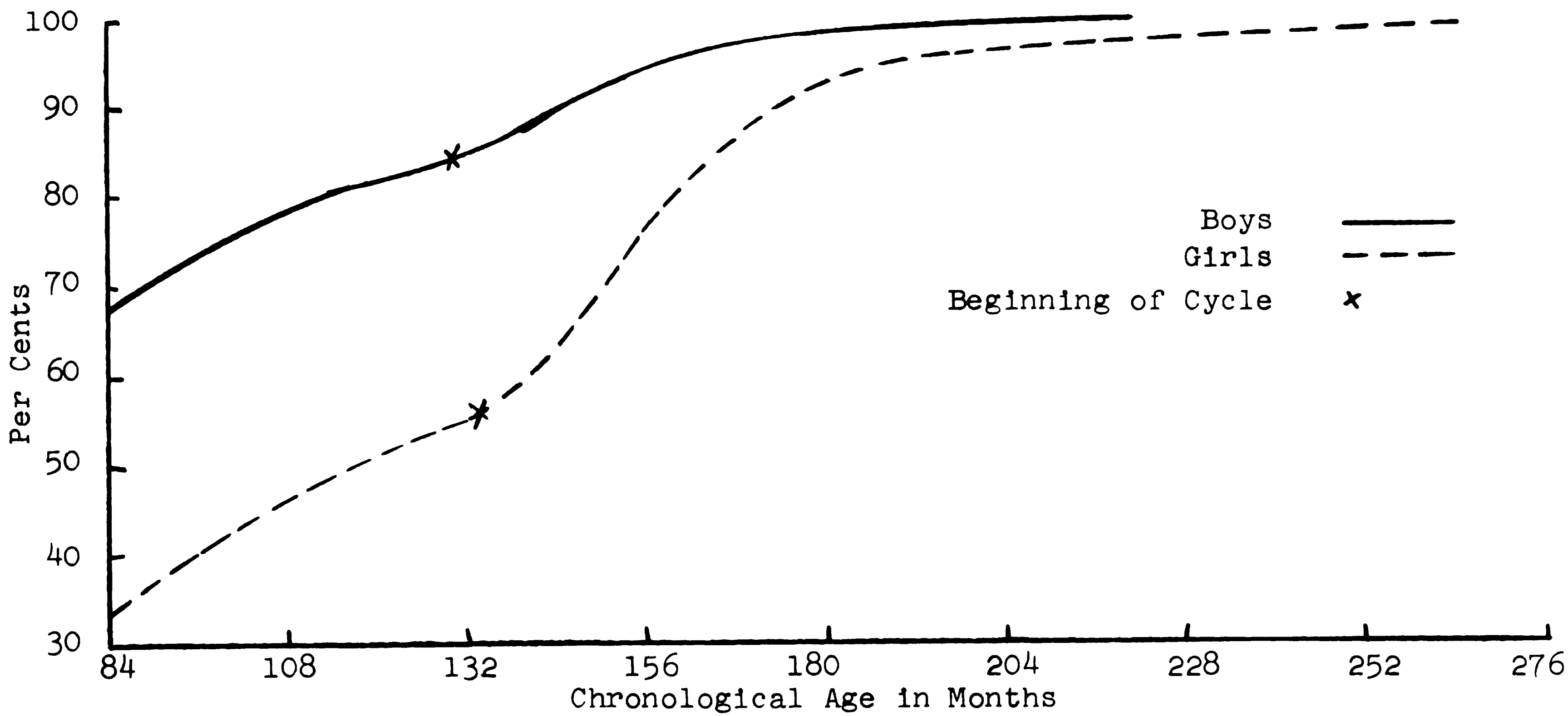


Figure 18. Curves of Total Maturity--Girls' Percentages

small correlations. This could be due to very small changes in magnitude, yet moderate changes in ranking. The compilation of means, and deviations from those means necessary for the last three figures, was a check upon the possibility of just such an occurrence.

The mean ages at which the adolescent cycles began are shown in Figure 19. The boys' mean starting time was 142.77 months for height and 143.85 months for weight. These two ages were quite close. However, the standard deviations of 8.83 months for height and 10.17 months for weight were large enough to show that prediction from the means would be unreliable.

The same holds true for girls' height and weight adolescent starting ages. The mean beginning time in height for the girls was 127.16 months with a standard deviation of 6.80 months. The mean beginning time in weight was 131.70 months with a standard deviation of 13.11 months. Once again the mean starting times were quite close, but both height and weight had large deviations. Therefore, the use of the girls' mean starting time of the adolescent cycle in either height or weight for prediction would be of doubtful value.

Due to large standard deviations, the chronological age at which the adolescent cycle began, has been shown to be of little predictive value. When starting ages for each case were converted into percentages of pre-adolescent

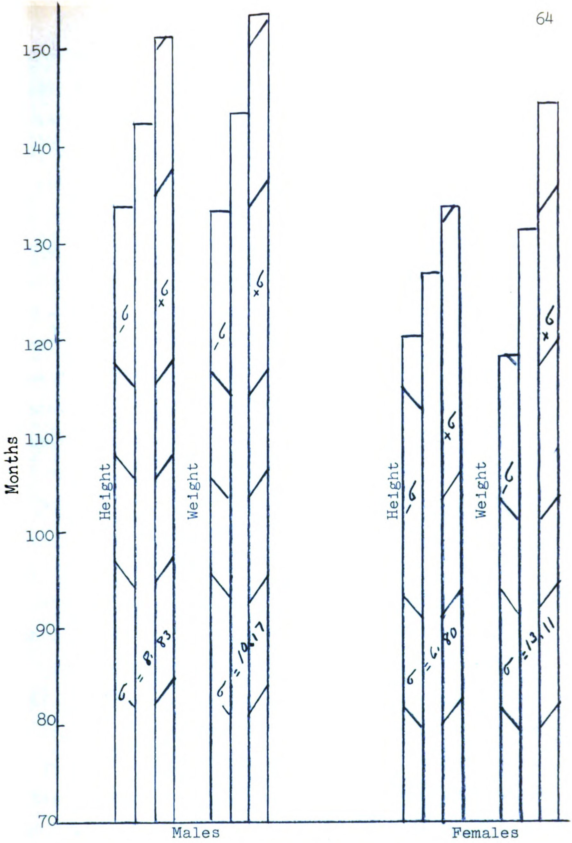


Figure 19. Age at which Adolescent Cycle Began

development, the standard deviations of height means for both boys and girls dropped to less than three per cent. The boys' mean of 91.43 per cent had a standard deviation of 2.97 per cent, while the girls' mean of 92.22 per cent had a standard deviation of 2.50 per cent. This is such a small deviation that it can be said that boys and girls adolescent height cycles start at 91.43 and 92.22 per cent of their respective pre-adolescent height development.

Weight per cent of pre-adolescent development at the beginning of the adolescent cycle, probably due to its fluctuations of values and subsequent difficulty of smoothing, still showed a large standard deviation for both boys and girls.

The girls' per cent of pre-adolescent development of 77.35 with a standard deviation of 9.71 was slightly better than the boys' 75.60 per cent with a standard deviation of 10.43 per cent. Though the mean starting per cents of development were close, the size of the standard deviations restricts their use for prediction.

Conversion of height and weight values to percentages of total maturity improved weight standard deviations, while leaving the height deviations approximately the same. The boys' height mean percentage of 81.10 with a standard deviation of 2.83 per cent, compared favorably with the girls' height mean of 82.96 per cent with a standard deviation of 3.08 per cent. Boys' weight mean per cent of

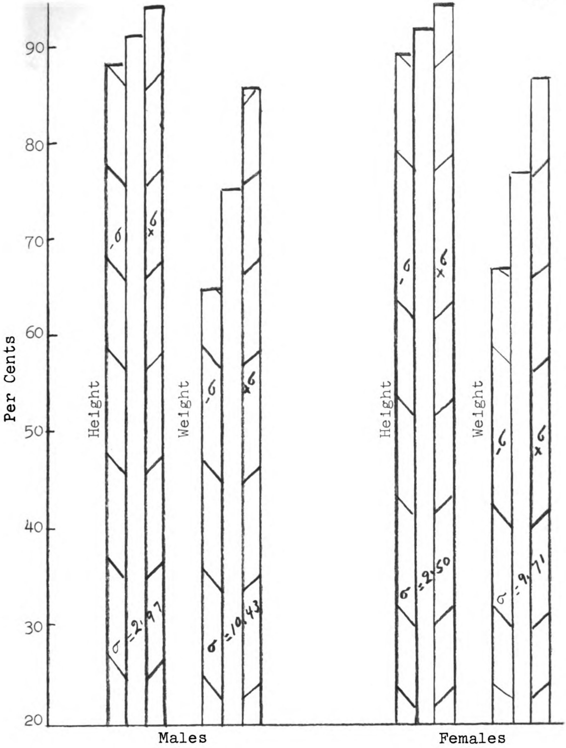


Figure 20. Per Cent of Pre-Adolescent Cycle Attained when Adolescent Cycle Began

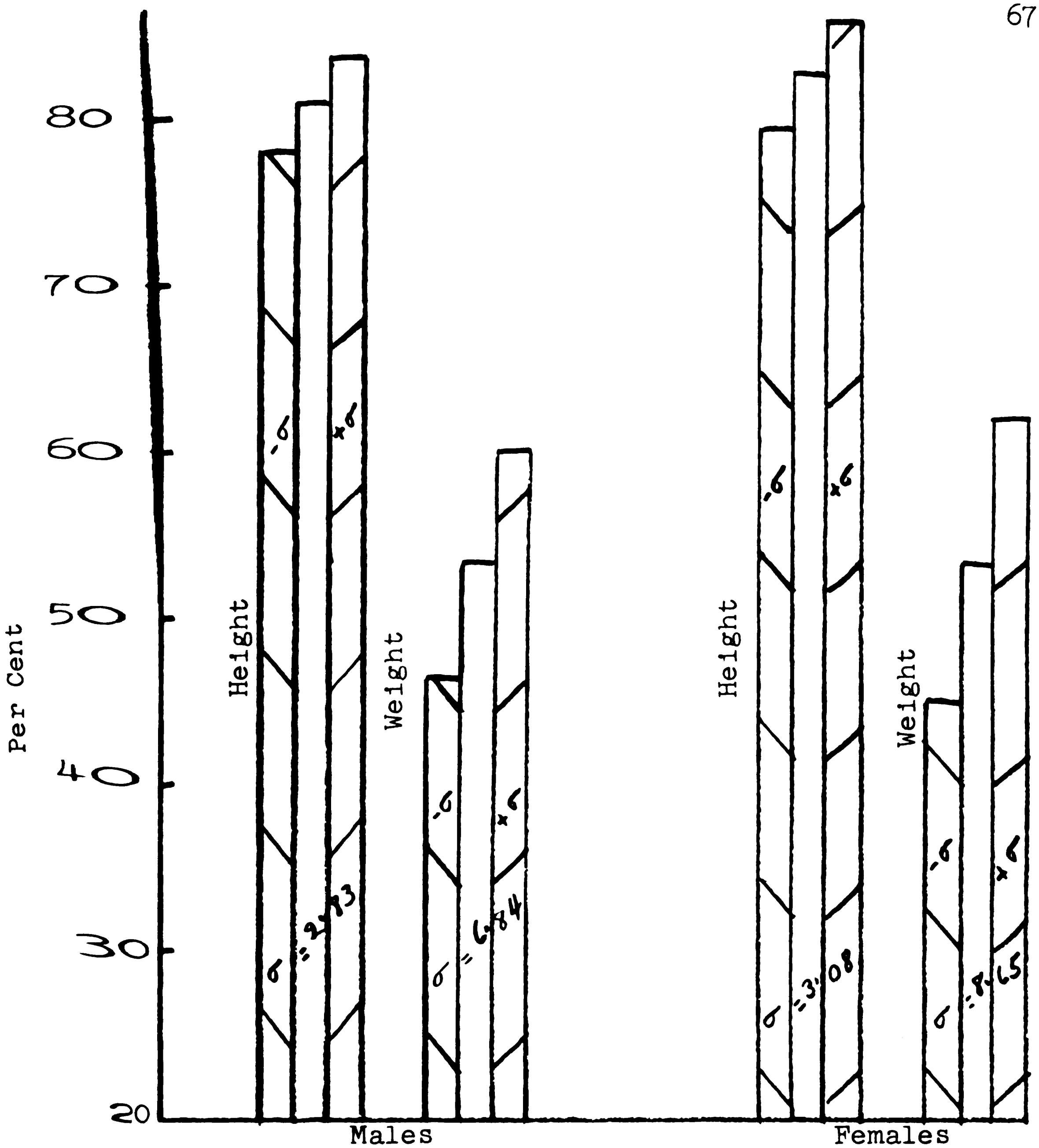


Figure 21. Per Cent of Total Development Attained at Beginning of Adolescent Cycle

53.48 with 6.84 as a standard deviation, and the girls' weight mean per cent of 53.76 with 8.65 per cent as a standard deviation were still a bit too large for predictive use.

The close agreement of height starting per cents of both boys and girls, and also weight starting per cents, suggested the possibility of equal starting percentages for each factor of growth regardless of sex.

The use of the Courtis method to derive starting points of the adolescent cycle has proved of little value as far as chronological age is concerned. It did prove of value when derived scores were changed to percentages of development. The comparison of mean starting percentages of both pre-adolescent and total growth produced likenesses of height starting percentages and weight starting percentages without considering sex. Height starting percentages of development were grouped closely about their mean, thus lending themselves to predictive use. Weight percentages of development were more dispersed from their means. Future studies may well show these starting percentages to be more similar.

CHAPTER V

SUMMARY, CONCLUSIONS, AND IMPLICATIONS

Summary

This study was conducted to test the accuracy with which the Courtis method describes height and weight growth, to test the use of correlative procedures on derivations of this technique, and to use extrapolation to arrive at new insights into growth.

All cases used in this study were selected from the Dearborn Data to meet the following criteria:

1. Measures must be included in a span of from 96 months through 180 months.
2. Each pre-adolescent and adolescent cycle must contain at least three measures of both height and weight.

The measures of twenty-six boys and eighteen girls met the above criteria.

Height and weight growth equations were written for each case by use of the Courtis method. Predicted measures were fitted as closely as possible to actual measures.

Cyclic starting and ending times were obtained by substituting the isocronic values for one per cent and 99 per cent respectively, for 'y' in the above equations

and solving for 't'. Values attained at one per cent of the adolescent cycle were obtained by substituting age at one per cent for 't' in the pre-adolescent equation and solving for 'y'. Percentages of development were obtained by dividing derived scores by proper maxima.

Conclusions

The Courtis method describes growth in height and weight well within a two per cent average deviation.* Height growth was described more accurately than weight growth. The Courtis method describes height and weight growth so accurately that it may be used to test for growth relationships through various statistical techniques.

The correlative findings were as follows:

1. Correlations between rates were generally positive. Some were significant at the five per cent level of confidence, but none were large enough to be used for prediction.

2. Correlations between maxima were generally positive--of which many were significant at the five per cent level. Four correlations were noticeably negative. They were those of pre-adolescent height maxima correlated with adolescent height maxima, and pre-adolescent weight maxima correlated with adolescent weight maxima. This would seem to indicate that large pre-adolescent maxima are followed by small adolescent maxima and vice versa. No correlations were large enough for predictive purposes.

*See pp. 42 and 43 for mean errors.

3. Correlations of ages at one per cent of adolescent growth, 99 per cent of pre-adolescent, and 99 per cent of adolescent growth are generally positive, but too low for predictive purposes.

4. Correlations between the values of height and weight attained at one per cent of the adolescent cycle, and corresponding maxima tended to verify the suggestion that larger pre-adolescent growth is followed by smaller adolescent growth, and smaller pre-adolescent growth is followed by larger adolescent growth.

5. Correlations of percentages of development at the beginning of the adolescent cycle were generally positive and significant but not large enough for predictive use.

The use of the Courtis method to find growth relationships through correlative techniques did not produce outstanding results. Correlations obtained between final maxima were no better than those noted in the Review of Literature.

Comparison of the curves of constants revealed the earlier maturing of girls, which caused them to be heavier and taller than the boys between the years of twelve to fourteen. Conversion of the curves of constants into percentages of total development curves disclosed similarities of adolescent starting ages, and percentages of total development at the beginning of adolescent development.

The mean ages at which the boys started their adolescent height cycles was within 1.08 months of the mean time of the starting of their weight cycles. The girls mean height cycle starting time was only 4.54 months before their mean weight cycle starting time. This close agreement of mean starting times would suggest the possibility of establishing a single starting age for factors of adolescent growth. Wide standard deviations somewhat diminshed such a possibility.

The means of boys and girls per cent of preadolescent height growth that was attained when the adolescent cycle began were within .79 per cent of each other. Mean weight per cents attained by boys and girls by the time the adolescent cycle began were within 1.75 per cent. These quite similar percentages would imply single percentage points at which height and weight adolescent growth would begin. Weight standard deviations were still large, but height standard deviations were small.

The mean percentages of total growth attained by boys and girls at the beginning of adolescent growth in height were within 1.86 per cent of each other. Mean weight percentages attained at a like time were only .28 per cent from one another. Weight deviations were reduced, and height deviations remained small. These figures added to the implication that single starting percentages of development may be found through further study.

Implications

In order to best describe growth by use of the Courtis method, accurate measuring of growth is essential. Courtis states that three measures are all that is necessary to define one cycle of growth. The writer would like to recommend that adequate describing of a cycle of growth demands at least four values within that cycle. Of course, the more values within a cycle, the more adequately that cycle can be described. This is especially true of weight, as weight values are prone to fluctuation. As many of the equations of this study are based upon three measures in a cycle, further research using data having more measures per cycle may prove the Courtis method of greater value.

This study has suggested the existence of several possible height--weight relationships, which are worthy of further study. The negative or reverse relationship between height and weight values attained at the time of the beginning of the adolescent cycle, and respective height and weight adolescent maxima, is one such area. The existence of a uniform age at which boys start their adolescent cycles in both height and weight, and girls, likewise, is another area. A third area for further study is the possibility of determining a uniform percentage of adolescent or total height and weight development, which must be attained before the adolescent cycle may begin. The Courtis method offers a precise procedure for the determination of the necessary age and percentage values. It is hoped that more research will employ this technique to good advantage.

BIBLIOGRAPHY

BIBLIOGRAPHY

Abernethy, Ethel M. "Relationships Between Mental and Physical Growth," Monographs of the Society for Research in Child Development, Vol. 1, No. 7, vii-80.

American Seating Company. Better Seating for America Through Research, Testing, Inspection. Grand Rapids, Michigan: American Seating Company, 1953.

Baldwin, B. T. "The Physical Growth of Children from Birth to Maturity," University of Iowa Studies of Child Welfare, 1921, Vol. 1, No. 1.

__________. "Physical Growth and Progress," Bulletin 10; U. S. Bureau of Education. Washington, D.C.: Government Printing Office, 1914.

Baldwin, B. T., et al. Height-Weight Age Tables. New York: American Child Health Association, 1923.

"Basic Body Measurements of School Age Children." U. S. Department of Health, Education and Welfare. Washington, D.C.: Government Printing Office, June, 1953.

Baum, M. P. and V. S. Vickers. "Anthropometric and Orthopedic Examinations: A Technique for Use with Children," Child Development Monographs, Vol. 12, No. 4, pp. 339-345.

Bayer, L. M. and Nancy Bayley. "Directions for Measures and Radiographs Used in Predicting Height," Child Development Monographs, 1947, Vol. 18, No. 3, pp. 85-87.

Bayley, Nancy. Studies in the Development of Young Children. Berkeley, California: University of California Press, 1940.

__________. "Tables for Predicting Adult Height from Skeletal Age and Present Height," Journal of Pediatrics, Vol. 28, 1946, pp. 49-64.

Bloomers, P., et al. "The Organismic Age Concept," Journal of Educational Psychology, 1955, Vol. 46, pp. 142-48.

Boaz, Franz. "Observations on the Growth of Children," Science, Vol. 27, No. 1854, July, 1930, pp. 44-48.

Bruch, Hilde. "Obesity in Childhood: I. Physical Growth and Development of Obese Children," American Journal of Diseases of Children, Vol. 58, No.3, pp. 457-484.

Children's Bureau of the United States Department of Labor. References on the Physical Growth and Development of the Normal Child, No. 179. Washington, D.C.: Government Printing Office, 1927.

Count de Buffon. "Sur l'accroissement successif des enfants, Gueneau de Montbeillard mesure of 1759 a 1776,". Oeuvres Completes. Paris: Furne and Pie, 1873, Vol. III, pp. 174-176.

Courtis, S. A. Maturation Units and How to Use Them. Ann Arbor, Michigan: Litho-printed. Edwards Bros.,1950.

__________. "Maturation As A Factor in Diagnosis," The 34th Yearbook of the Society for the Study of Education, 1935.

__________. "Maturation Units for the Measurement of Growth," School and Society, 1929, Vol. 30, pp.683-690.

__________. The Measurement of Growth. Ann Arbor, Michigan: Brumfield and Brumfield, 1932.

__________. Towards A Science of Education. Ann Arbor, Michigan: Edwards Brothers, 1951.

__________. "What Is A Growth Cycle?," Growth, 1937, Vol.I, No. 4, pp. 155-174.

Croxton, F. E. and D. J. Cowder. Applied General Statistics. New York: Prentice-Hall, Inc., 1939.

Dana, Margaret. Behind the Label. Boston: Little,Brown and Company, 1938.

Davenport, C. B. "Human Growth Curve," Journal of General Physiology, 1926, Vol. 10, pp. 205-216.

Dearborn, W. F. and J. W. M. Rothney. "Basing Weight Standards Upon Linear Bodily Dimensions," Growth, 1938, Vol. 2, No. 2, pp. 197-212.

__________. Predicting the Child's Development. Cambridge, Mass.: Sci-Art Pub., 1941.

DeLong, A. R. "The Relative Usefulness of Longitudinal and Cross-Sectional Data." Paper presented to the Michigan Academy of Science, Arts, and Letters, March 26, 1955.

Fitt, A. B. "Seasonal Influence on Growth Function and Inheritance," New Zeland Council for Educational Research. New Zeland: Whitcombe and Tombs, Ltd., 1941.

Flanagan, J. C. "Units, Scores, and Norms," Educational Measurement, ed. E. F. Lindquist. Washington, D. C.: American Council of Education, 1951.

Flory, C. D. "Osseos Development in the Hand as an Index of Skeletal Development," Monographs of the Society for Research in Child Development, Vol. 1, No. 3, pp. ix-141.

Frank, L. K. Child Behavior and Development. Eds. Barker, Kounin and Wright. New York: McGraw Hill Book Co., 1943.

Garn, S. M. "Individual and Group Deviations from 'Channel-wise' Grid Progression in Girls," Child Development Monographs, Vol. 23, No. 3, pp. 193-206.

Gesell, Arnold and Catherine S. Amatruda. Developmental Diagnosis. New York: Paul B. Hoeber, Inc., 1952.

Grandprey, M. B. "Range in Variability in Weight and Height of Children Under Six Years of Age," Child Development Monographs, 1933, No. 1, pp. 26-35.

Gray, H. "Individual Growth-Rates; From Birth to Maturity for Fifteen Physical Traits," Human Biology, 1941, Vol. 13, No. 3, pp. 306-333.

Greulich, W. W. "The Rationale of Assessing the Developmental Status of Children from Roentgenograms of the Hand and Wrist," Child Development, 1950, Vol. 21, pp. 33-44.

__________. "Some Observations on the Growth and Development of Adolescent Children," The Journal of Pediatrics, 1941, Vol. 19, pp. 302-314.

Hamilton, Andrew. "You Can Tell How Tall Your Child Will Grow," Colliers, August 9, 1952.

Hollingshead, A. B. Elmtown's Youth. New York: John Wiley and Sons, Inc., 1949.

Hrdlicka, Ales. Practical Anthropometry. Philadelphia: Wister Institute of Anatomy and Biology, 1920.

Huggett, A. J. and C. V. Millard. Growth in Learning in the Elementary School. Boston: D. C. Heath and Company, 1946.

Jackson, C. M. "Normal and Abnormal Human Types," Measurement of Man. Minneapolis, Minnesota: University of Minnesota Press, 1930, Vol. 86.

Jens, R. N. and Nancy Bayley. "A Mathematical Method for Studying the Growth of Children," Human Biology, 1937, Vol. 9, pp. 556-563.

Jersild, Arthur T. The Psychology of Adolescence. New York: The Macmillan Company, 1957.

Jones, H. E. "Relationships in Physical and Mental Development," Review of Educational Research, 1933, No. 3, pp. 150-162.

Knott, V. B. "Physical Measurement of Young Children," University of Iowa Studies: Studies in Child Welfare, Vol. 18, No. 3.

Kornfeld, W. "Technical Aspects of the Analysis of Bodily Conformation in Children," American Journal of Diseases of Children, Vol. 55, pp. 835 836.

Kowitz, Gerald T. "An Exploration into the Relationship of Physical Growth Pattern and Classroom Behavior in Elementary School Children." Unpublished Ph.D. thesis, Department of Education, Michigan State College, 1954.

Krogman, W. M. "The Physical Growth of Children: An Appraisal of Studies 1950-1955," Monographs of the Society for Research in Child Development, Inc., 1956, Vol. 60, No. 10, pp. iii-91.

__________. "A Handbook of the Measurement and Interpretation of Height and Weight in the Growing Child," Monographs of the Society for Research in Child Development, 1948, Vol. 13, No. 3, pp. ix-68.

Leeson, H. J., et al. "The Value of the Wetzel Grid in the Examination of School Children," Canadian Journal of Public Health, 1947, Vol. 38, pp. 491-495.

Massler, Maury. "Calculation of Normal Weight," Child Development Monographs, 1945, Vol. 16, Nos. 1 and 2.

McCloy, Charles H. "Appraising the Physical Status--The Selection of Measurements," University of Iowa Studies, Vol. 12, No. 2.

Meredith, H. V. "Physical Growth of White Children, A Review of American Research Prior to 1900," Monograph of the Society for Research in Child Development, 1936, Vol. 1, No. 2, pp. 1-83.

__________. "The Prediction of Stature of North European Males Throughout the Elementary School Years," Human Biology, 1938, Vol. 8, No. 2, pp. 279-283.

__________. "The Rhythm of Physical Growth," University of Iowa Studies, 1935, Vol. 11, No. 3.

Meredith, Howard V. and Matilda E. Meredith. "Annual Increment Norms for Ten Measures of Physical Growth on Children Four to Eight Years of Age," Child Development Monographs, Vol. 21, No. 3, pp. 141-148.

Meredith, H. V. and G. Stoddard. "Physical Growth from Birth to Maturity," Review of Educational Research, 1936, Vol. 6, pp. 54-84.

Millard, Cecil V. "An Analysis of Factors Conditioning Performance in Spelling." Unpublished Ph. D. thesis, School of Education, University of Michigan, 1937.

__________. Child Growth and Development in the Elementary School Years. Boston: D. C. Heath Company, 1951.

__________. "The Nature and Character of Pre-Adolescent Growth in Reading Achievement," Child Development Monographs, Vol. 11, No. 2, 1940, pp. 71-114.

Millard, C. V. and J. W. M. Rothney. The Elementary School Child: A Book of Cases. New York: The Dryden Press, 1957.

Miller, R. Bretney. "Physique, Personality and Scholarship, A Comparative Study of School Children," Monographs of the Society for Research in Child Development, 1943, Vol. VIII, No. 1, pp. 25-121.

Munn, Norman L. The Evolution and Growth of Human Behavior. New York: Houghton Mifflin Company, 1955.

Nally, Thomas P. F. "The Relationship Between Achieved Growth in Height and the Beginning of Growth in Reading." Unpublished Ph.D. thesis, Department of Education, Michigan State College, 1953.

Nally, T. P. F. and A. R. DeLong. "An Appraisal of Method of Predicting Growth," Child Development Laboratory Publication, Series II, No. 1, East Lansing, Michigan, 1952.

Olson, Willard C. and Byron O. Hughes. "Growth of the Child as a Whole," Chapter 12, in Barker, Kounin and Wright, Child Behavior and Development. New York: McGraw-Hill Book Company, Inc., 1943.

Palmer, C. E., et al. "Anthropometric Studies of Individual Growth. II. Age, Weight, and Rate of Growth in Weight, Elementary School Children," Child Development, Vol. 8, No. 1, pp. 47-61.

Pickard, Edwin C. Ford Motor Company Engineer. A Passenger Car Comfort and Seat Design. Paper presented at SAE Meeting, 1956.

Prescott, R. D. "Law of Growth in Forecasting Demand," Journal of the American Statistical Association, 1922, Vol. 18, No. 140, pp. 471-479.

Pryor, Helen B. "Width-Weight Tables (Revised)," American Journal of Diseases of Children, Vol. 61, pp. 300-304.

Quetelet, A. Anthropometrie. Bruxelles: Muquardt,1871.

Reynolds, E. A. and L. W. Sontag. "Seasonal Variations in Weight, Height, and Appearance of Ossification Centers," The Journal of Pediatrics, 1944, Vol. 24, pp. 524-535.

Robinow, Meinhard. "The Variability of Weight and Height Increments from Birth to Six Years," Child Development, June, 1942, Vol. 13, No. 2, pp. 159-164.

Rusch, Reuben R. "The Relationship Between Growth in Height and Growth in Weight." Unpublished M. A. thesis, Department of Education, Michigan State College, 1954.

Sheldon, W. H., et al. The Varieties of Human Physique. New York: Harper Brothers, 1940.

Shock, N. S. "Growth Curves," Handbook of Experimental Psychology. New York: John Wiley, 1951.

Shuttleworth, Frank K. "Standard of Development in Terms of Increments," Child Development Monographs, 1934, Vol. 1, pp. 89-91.

Simmons, Katherine. "The Brush Foundation Study of Child Growth and Development: II. Physical Growth and Development," Monograph of the Society for Research in Child Development, 1944, Vol. 9, No. 1, xvii-87.

Simmons, K. and T. W. Todd. "Growth of Well Children: Analysis of Stature and Weight, Three Months to Thirteen Years," Growth, 1938, Vol. 2, pp. 93-134.

Sims, Verner M. The Measurement of Socio-Economic Status. Bloomington, Illinois: Bloomington Public Schools Publishing Company, 1928.

Souther, Susan P., et al. "A Comparison of Indices Used in Judging Physical Fitness of School Children," American Journal of Public Health, 1939, Vol. 29, pp. 434-438.

Steggerda, M. "A Height-Weight-Age Table for Navahoes, 6-18 Years; A Height-Weight-Age Table for Dutch Whites, 6-15 Years, Measured in Holland, Michigan." Washington, D. C.: Carnegie Institute, 1936.

Stolz, H. R. and L. M. Stolz. Somatic Development of Adolescent Boys. New York: The Macmillan Company, 1951.

Strang, Ruth. An Introduction to Child Study. New York: The Macmillan Company, 1951.

Stroud, J. B. Psychology in Education. New York: Longmans, Green and Company, 1956.

Stuart, H. C., and Staff. "The Center for Research in Child Health and Development, School of Public Health, Harvard University, I., Monograph of the Society for Research in Child Development, Vol. 4, No. 1, pp. xiv-261.

Terman, L. M. and Maud A.Merrill. Measuring Intelligence. Boston: Houghton Mifflin Company, 1939.

Thompson, Helen. Manual of Child Psychology, Ed. Leonard Charmichael. New York: John Wiley and Sons, Inc., 1946.

Todd, W. T. Atlas of Skeletal Maturation. St. Louis: Mosby Publishing Co., 1937.

Turner, C. E. and Alfred Nordstrom. "Extent and Seasonal Variations of Intermittency in Growth," American Journal of Public Health, 1938, Vol. 28, pp. 499-505.

Tyler, Fred T. "Concepts of Organismic Growth: A Critique," Journal of Educational Psychology, 1955, Vol.46,p.321-42.

___________. "Organismic Growth: P Technique in the Analysis of Longitudinal Growth Data," Child Development, 1954, Vol. 25, No. 2, pp.85-93.

Udoh, Ekanem A. "Relationship of Menarch to Achieved Growth in Height." Unpublished Ph.D. thesis, Department of Education, Michigan State College, 1955.

Walker, H. M. and J. Lev. Statistical Inference. New York: Henry Holt and Company, 1953.

Wallis, Ruth S. "How Children Grow, An Anthropometric Study of Private School Children from Two to Eight Years of Age," University of Iowa Studies in Child Welfare, Vol. 5, No. 1.

Warner, W. L., et al. Social Class in America. Chicago: Science Research Associates, Inc., 1949.

Wetzel, Norman C. The Treatment of Growth Failure in Children. Cleveland, Ohio: NEA Service, Inc., 1948.

Winsor, C. P. "The Gompertz Curve as a Growth Curve," Proceedings of the National Academy of Sciences, 1932, Vol. 18, No. 1, pp. 1-8.

Wolff, George. "A Study of Height in White School Children from 1937 to 1940 and a Comparison of Different Height-Weight Indices," Child Development Monographs, 1942, Vol. 13, No. 1, pp. 65-77.

Wood, T. D. "Health Examination," Ninth Yearbook, National Society for the Study of Education, 1910, Vol. 9, Part 1.

APPENDICES

APPENDIX A

FREQUENCY AND RANGE OF MEASURES--BOYS

Case No.	No. of Height Measures	No. of Weight Measures	Range of Height Measures (Mos.)	Range of Weight Measures (Mos.)
27M	17	10	73 - 166	73 - 175
31M	17	8	90 - 171	90 - 174
42M	17	10	59 - 164	59 - 167
44M	17	10	68 - 169	68 - 176
45M	22	10	66 - 183	66 - 174
50M	19	10	74 - 182	74 - 182
51M	21	10	71 - 188	71 - 179
55M	17	11	64 - 165	64 - 166
61M	17	9	65 - 161	101 - 179
65M	17	11	85 - 185	97 - 187
71M	17	9	67 - 163	89 - 175
77M	15	10	92 - 185	93 - 182
80M	13	8	104 - 173	105 - 170
83M	17	12	77 - 173	77 - 191
87M	17	11	80 - 181	88 - 178
110M	12	8	100 - 181	112 - 178
115M	14	9	81 - 170	89 - 167
129M	14	7	89 - 178	97 - 169
136M	14	10	85 - 178	85 - 175
162M	12	9	81 - 165	89 - 167
163M	17	11	77 - 177	84 - 174
164M	17	11	72 - 168	72 - 174
167M	17	9	76 - 172	76 - 172
171M	17	10	82 - 182	89 - 179
176M	15	8	85 - 179	85 - 181
195M	15	8	91 - 191	99 - 182

APPENDIX B

FREQUENCY AND RANGE OF MEASURES--GIRLS

Case No.	No. of Height Measures	No. of Weight Measures	Range of Height Measures (Mos.)	Range of Weight Measures (Mos.)
52F	18	7	90 - 171	91 - 162
55F	18	7	76 - 169	76 - 160
58F	17	13	67 - 175	67 - 181
59F	17	12	109 - 178	110 - 175
62F	18	10	64 - 181	64 - 172
64F	18	9	90 - 181	81 - 165
65F	18	8	81 - 174	81 - 165
69F	17	10	62 - 162	62 - 170
71F	17	12	67 - 175	79 - 175
78F	17	9	76 - 172	76 - 172
80F	17	12	76 - 181	76 - 178
84F	17	9	58 - 159	70 - 166
97F	14	9	79 - 168	88 - 165
105F	12	8	109 - 178	89 - 169
118F	13	9	94 - 175	94 - 172
189F	12	9	108 - 189	109 - 186
190F	15	8	87 - 180	87 - 171
227F	14	9	80 - 169	89 - 166

APPENDIX C

INDIVIDUAL INTELLIGENCE QUOTIENTS

Males		Females	
Case No.	I. Q.	Case No.	I. Q.
27M	111.2	52F	106.8
31M	106.3	55F	125.6
42M	111.4	58F	94.5
44M	117.2	59F	104.7
45M	110.2	62F	106.8
50M	97.3	64F	108.2
51M	120.5	65F	107.2
55M	104.8	69F	103.5
61M	103.1	71F	110.7
65M	86.8	78F	109.9
71M	112.3	80F	101.3
77M	103.0	84F	112.7
80M	104.2	97F	109.0
83M	86.1	105F	108.5
87M	121.5	118F	100.3
110M	99.0	189F	93.6
115M	110.0	190F	103.2
129M	117.0	227F	121.6
136M	122.2		
162M	109.0		
163M	121.5		
164M	104.0		
167M	104.6		
171M	109.5		
176M	101.2		
195M	79.2		
Average I.Q.	106.7		107.1
Total Average I.Q.		106.8	

APPENDIX D

HEIGHT FORMULAS--BOYS

Case No.	Pre-Adolescent Cycle			Adolescent Cycle			Total Maximum
	Maximum	Rate	Incipiency	Maximum	Rate	Incipiency	
27M	64	.23366	+23.05	10	.70450	- 83.51	74.0
31M	66	.11662	+28.59	5	1.22556	-191.88	71.0
42M	67	.14117	+29.90	7	1.00235	-132.73	74.0
44M	58	.28073	+21.04	13	.43722	- 42.39	71.0
45M	63.5	.22000	+23.61	6.7	.93167	-122.03	70.2
50M	59	.20000	+23.84	6	.95583	-128.16	65.0
51M	58.5	.37875	+ 9.48	9.6	.73750	- 83.68	68.1
55M	66	.19805	+25.18	9	.56333	- 57.52	75.0
61M	62	.20893	+24.27	7	.65235	- 81.92	69.0
65M	61	.13778	+28.23	6	.66333	- 78.14	67.0
71M	62	.17372	+27.87	9	.47621	- 50.10	71.0
77M	64	.31458	+13.91	6	.64929	- 78.70	70.0
80M	64	.27379	+17.98	7	.64952	- 76.30	71.0
83M	61	.19917	+25.39	10	.45500	- 48.79	71.0
87M	64	.23806	+19.25	5	.71833	- 91.48	69.0
110M	60	.30306	+18.05	12	.59750	- 72.54	72.0
115M	64	.21718	+22.54	8	.50375	- 53.44	72.0
129M	59	.16813	+27.61	10	.63824	- 80.35	69.0
136M	64	.22458	+20.96	7	.93696	-115.67	71.0
162M	66.7	.30464	+13.22	7	.96500	-129.26	77.7
163M	68	.27824	+13.66	7	1.02429	-138.85	75.0
164M	61	.21491	+23.74	7	.46353	- 51.73	68.0
167M	58	.33448	+15.23	9	.67324	- 71.02	67.0
171M	60	.27537	+18.16	8	.75895	- 98.21	68.0
176M	62	.17500	+28.39	5	.51667	- 62.97	67.0
195M	65	.23105	+21.72	6.6	.94139	-111.33	71.6
Average Case	62.6	.23237	+21.73	7.8	.72467	- 89.76	70.4

APPENDIX E

WEIGHT FORMULAS--BOYS

Case No.	Pre-Adolescent Cycle			Adolescent Cycle			Total Maximum
	Maximum	Rate	Incipiency	Maximum	Rate	Incipiency	
27M	122	.13286	+20.91	53	1.01333	-134.63	175
31M	125	.10333	+19.22	10	1.78083	-266.88	135
42M	85	.21771	+19.84	37	1.19667	-146.29	122
44M	81	.25600	+14.91	72	.53667	- 56.85	153
45M	115	.18453	+17.20	50	.67875	- 88.50	165
50M	103	.11944	+20.72	42	.80000	-103.95	145
51M	100	.24944	+10.84	45	.87917	-110.06	145
55M	116	.16806	+17.46	70	.59278	- 65.28	186
61M	110	.15806	+17.71	41	.54778	- 65.42	151
65M	125	.12306	+18.36	38	.95125	-129.71	163
71M	90	.33000	+ 3.09	48	.50458	- 50.93	138
77M	97	.31742	+ 3.93	35	.45833	- 52.21	132
80M	95	.35000	+ 4.30	45	.87278	-109.20	140
83M	95	.19917	+15.04	45	1.02944	-154.41	140
87M	105	.29429	+ 3.47	30	1.29333	-180.36	135
110M	130	.15250	+15.97	50	.80833	-114.44	180
115M	95	.16556	+19.69	50	.60750	- 71.74	145
129M	110	.11400	+22.08	13.6	.64308	- 64.26	123.6
136M	98.5	.26957	+ 5.75	45	.90833	-115.78	143.5
162M	110	.26333	+ 8.96	25	1.19500	-158.00	135
163M	115	.26417	+ 9.51	70	.62467	- 72.97	185
164M	145	.09542	+20.23	16	1.08667	-144.91	161
167M	95	.23000	+14.82	93	.54542	- 55.90	188
171M	100	.19542	+14.80	45	.70357	- 90.74	145
176M	90	.11979	+23.51	24	.45542	- 50.66	114
195M	110	.20211	+15.93	41	.79056	- 91.69	151
Average Case	106.25	.20289	+14.55	43.6	.82709	-105.61	149.85

APPENDIX F

HEIGHT FORMULAS--GIRLS

Case No.	Pre-Adolescent Cycle			Adolescent Cycle			Total Maximum
	Maximum	Rate	Incipiency	Maximum	Rate	Incipiency	
52F	61	.32474	+14.09	4.8	.92179	-100.72	65.8
55F	60	.44412	+ .54	7.4	.83750	- 90.42	67.4
58F	59	.25750	+21.96	10	.42075	- 40.21	69.0
59F	59	.17939	+26.85	7	.61650	- 71.11	66.0
62F	58.7	.35917	+14.56	8	.64071	- 63.61	66.7
64F	58.5	.47226	+ 1.40	5.8	1.43250	-173.81	64.3
65F	58.5	.28333	+22.57	4.8	1.06917	-114.44	63.3
69F	64	.23194	+23.25	5	.73167	- 74.74	69.0
71F	61	.26556	+22.18	5.8	.74200	- 72.65	66.8
78F	61	.17528	+29.25	6	.84032	- 90.34	67.0
80F	51	.42476	+ 9.01	10.2	.78464	- 85.46	61.2
84F	59	.39789	+ 6.82	5.8	.91882	- 99.89	64.8
97F	60	.34875	+ 9.61	3.2	1.28412	-165.09	63.2
105F	56	.26333	+22.23	8	.67675	- 67.05	64.0
118F	58	.30167	+15.94	7	.98917	-117.71	65.0
189F	60	.31375	+12.78	8.2	.58857	- 61.13	68.2
190F	60	.22903	+22.69	5	1.51889	-190.56	65.0
227F	62	.22250	+24.88	6.7	.68333	- 65.39	68.7
Average Case	59.3	.30528	+16.70	6.6	.87207	- 96.91	65.9

APPENDIX G

WEIGHT FORMULAS--GIRLS

Case No.	Pre-Adolescent Cycle			Adolescent Cycle			Total Maximum
	Maximum	Rate	Incipiency	Maximum	Rate	Incipiency	
52F	90	.16087	+22.89	53	.58375	- 51.23	143
55F	63	.33444	+12.64	60	.52333	- 45.22	123
58F	76	.35617	+ 5.92	38	1.23778	-170.60	114
59F	80	.30042	+ 7.45	35	.62875	- 70.44	115
62F	83.1	.33750	+ 7.51	49.2	.79250	- 83.92	132.3
64F	147	.33833	+ .19	62.5	1.22333	-156.28	209.5
65F	105	.09625	+26.36	45	.46250	- 34.63	150
69F	126	.26417	+ 6.99	32	1.50750	-206.01	158
71F	79.5	.21611	+18.58	30	1.26467	-145.63	109.5
78F	110	.16486	+17.89	40	.66667	- 74.08	150
80F	81	.11938	+21.59	45	.79167	- 90.93	126
84F	105	.12639	+21.96	34.5	1.03333	-114.22	139.5
97F	94	.28583	+ 5.99	18.6	1.73333	-231.70	112.6
105F	66	.14818	+29.99	70	.45306	- 37.95	136
118F	92	.25455	+ 7.22	30	1.22611	-163.71	122
189F	100.5	.22229	+ 8.85	32	.71111	- 92.26	132.5
190F	95	.23139	+12.63	36	.74000	- 85.46	131
227F	115	.22958	+10.09	25	.74700	- 84.19	140
Average Case	94.89	.23260	+13.60	40.88	.90702	-107.69	135.77

APPENDIX H--1

DEVIATION OF MEASURED HEIGHT SCORES FROM PREDICTED HEIGHT SCORES

Case No.	Age	Measured Inches	Predicted Inches	Deviations	Average Deviation
27M	97	52.0	52.0	0	
	109	54.5	54.72	+.22	
	114	55.5	55.68	+.18	
	121	57.0	56.83	-.17	
	126	57.1	56.96	-.14	
	130	58.0	58.14	+.14	
	133	58.6	58.51	-.09	
	138	59.1	59.16	+.06	
	142	60.1	59.74	-.36	
	145	60.3	60.26	-.04	
	150	61.2	61.38	+.18	
	154	62.5	62.5	0	
	157	63.4	63.43	+.03	
	162	65.1	65.06	-.04	
	166	66.1	66.33	+.23	
	169	67.0	67.21	+.21	
	174	68.5	68.5	0	
	176	69.0	69.0	0	.116
31M	90	44.5	44.09	-.41	
	102	46.5	46.5	0	
	114	49.2	48.68	-.52	
	119	49.5	49.5	0	
	123	50.0	50.16	+.16	
	126	50.6	50.62	+.02	
	131	51.0	51.41	+.41	
	135	52.0	52.01	+.01	
	138	52.2	52.40	+.20	
	143	53.0	53.13	+.13	
	147	53.4	53.66	+.26	
	150	53.6	54.02	+.42	
	155	54.4	54.65	+.25	
	159	55.0	55.11	+.11	
	162	55.5	55.44	-.06	
	167	56.0	56.02	+.02	
	171	56.5	56.6	+.10	
	174	57.2	57.2	0	
	179	58.6	58.61	+.01	
	183	60.1	60.1	0	.115

APPENDIX H--1 (Continued)

Case No.	Age	Measured Inches	Predicted Inches	Deviations	Average Deviation
42M	71	46.6	46.23	-.37	
	83	49.0	49.0	0	
	95	51.4	51.45	+.05	
	107	54.0	53.60	-.40	
	112	54.3	54.4	+.10	
	119	55.2	55.51	+.31	
	124	55.5	56.21	+.71	
	131	57.1	57.15	+.05	
	136	58.0	57.75	-.25	
	143	58.6	58.61	+.01	
	148	59.4	59.24	-.16	
	152	60.5	59.98	-.52	
	155	60.7	60.7	0	
	160	62.2	62.28	+.08	
	164	63.0	63.64	+.64	
	167	65.0	64.65	-.35	
	172	66.1	66.1	0	
	176	66.5	67.0	+.50	.250
44M	92	48.2	48.2	0	
	104	51.0	50.81	-.19	
	116	52.7	52.78	+.08	
	121	53.3	53.43	+.13	
	128	54.3	54.3	0	
	133	54.7	54.91	+.21	
	137	55.5	55.44	-.06	
	140	55.3	55.88	+.58	
	145	57.0	56.73	-.27	
	149	57.5	57.5	0	
	152	58.0	58.16	+.16	
	157	59.0	59.33	+.33	
	161	60.4	60.33	-.07	
	164	60.4	61.07	+.67	
	169	62.5	62.28	-.22	
	176	63.5	63.97	+.47	
	181	65.6	64.94	-.66	
	185	65.7	65.7	0	.227
45M	102	52.1	51.94	-.16	
	114	54.4	54.4	0	
	119	55.4	55.31	-.09	
	123	55.4	55.94	+.54	
	126	56.4	56.39	-.01	
	131	56.4	57.09	+.69	
	135	57.1	57.59	+.49	

APPENDIX H--1 (Continued)

Case No.	Age	Measured Inches	Predicted Inches	Deviations	Average Deviation
45M con't.	138	58.0	58.0	0	
	143	58.6	58.56	-.04	
	147	58.6	59.0	+.40	
	150	59.5	59.5	0	
	155	60.4	60.42	+.02	
	159	61.7	61.47	-.23	
	162	62.4	62.4	0	
	167	63.6	63.85	+.25	
	171	64.7	64.91	+.21	
	174	65.2	65.61	+.41	
	179	66.7	66.54	-.16	
	183	67.1	67.12	+.02	.196
50M	98	45.4	45.43	+.03	
	110	47.6	48.06	+.46	
	122	50.2	50.2	0	
	127	51.0	50.98	-.02	
	134	51.7	51.98	+.28	
	139	52.3	52.6	+.30	
	143	53.0	53.04	+.04	
	146	53.4	53.41	+.01	
	151	54.2	54.04	-.16	
	155	54.7	54.68	-.02	
	158	55.3	55.3	0	
	163	56.4	56.62	+.22	
	167	58.0	57.78	-.22	
	170	58.6	58.6	0	
	175	60.1	59.82	-.28	
	179	60.6	60.61	+.01	
	182	61.2	61.08	-.12	.128
51M	107	51.1	51.1	0	
	119	53.7	53.7	0	
	124	54.4	54.46	+.06	
	131	55.4	55.44	+.04	
	136	56.6	56.14	-.46	
	140	57.0	56.85	-.15	
	143	57.5	57.5	0	
	148	59.0	58.86	-.14	
	152	60.1	60.08	-.02	
	155	61.0	60.96	-.04	
	160	62.4	62.47	+.07	
	164	64.0	63.51	-.49	
	167	64.2	64.2	0	
	172	65.2	65.2	0	

APPENDIX H--1 (Continued)

Case No.	Age	Measured Inches	Predicted Inches	Deviations	Average Deviation
51M con't.	176	65.7	65.78	+.08	
	179	66.0	66.17	+.17	
	184	67.0	66.69	-.31	
	188	67.0	66.97	-.03	.114
55M	88	49.7	49.7	0	
	100	52.6	52.8	+.20	
	112	55.3	55.34	+.04	
	117	56.2	56.27	+.07	
	124	57.5	57.45	-.05	
	129	58.2	58.31	+.11	
	133	59.3	59.01	-.29	
	136	59.6	59.6	0	
	141	60.5	60.71	+.21	
	145	61.7	61.73	+.03	
	148	62.6	62.5	-.10	
	153	62.8	63.92	+1.12	
	157	65.0	65.0	0	
	160	65.4	65.77	+.37	
	165	67.4	67.07	-.33	
	169	68.0	68.0	0	.183
61M	89	47.4	47.06	-.36	
	101	50.0	50.0	0	
	113	52.3	52.45	+.15	
	117	53.1	53.17	+.07	
	125	54.4	54.44	+.04	
	129	55.0	55.0	0	
	137	56.2	56.05	-.15	
	141	56.4	56.49	+.09	
	146	58.1	57.05	-1.05	
	149	58.1	57.38	-.72	
	153	58.1	57.91	-.19	
	158	59.1	58.71	-.39	
	161	59.3	59.27	-.03	.217
65M	90	43.4	43.19	-.21	
	97	44.6	44.6	0	
	102	45.6	45.51	-.09	
	109	46.4	46.76	+.36	
	121	48.6	48.68	+.08	
	133	50.4	50.4	0	
	138	51.1	51.09	-.01	
	145	52.1	52.1	0	
	150	53.1	53.02	-.08	

APPENDIX H--1 (Continued)

Case No.	Age	Measured Inches	Predicted Inches	Deviations	Average Deviation
65M con't.	157	54.3	54.54	+.24	
	162	55.0	55.74	+.74	
	166	56.4	56.69	+.29	
	169	57.7	57.36	-.34	
	174	58.6	58.42	-.18	
	181	59.7	59.7	0	
	185	60.0	60.33	+.33	.184
71M	79	45.2	45.32	+.12	
	84	46.5	46.5	0	
	91	47.6	48.05	+.45	
	103	50.0	50.41	+.41	
	115	52.4	52.42	+.02	
	120	52.7	53.13	+.43	
	127	54.1	54.11	+.01	
	132	54.7	54.75	+.05	
	139	55.6	55.65	+.05	
	144	56.7	56.43	-.27	
	148	57.6	57.08	-.52	
	151	57.6	57.6	0	
	156	58.5	58.6	+.10	
	160	59.5	59.46	-.04	
	163	59.5	60.16	+.66	.189
77M	116	56.2	56.2	0	
	128	58.1	58.56	+.46	
	140	60.2	60.22	+.02	
	145	60.6	60.82	+.22	
	152	61.7	61.78	+.08	
	157	62.6	62.6	0	
	161	63.5	63.34	-.16	
	164	63.6	63.93	+.33	
	169	64.4	64.9	+.50	
	173	65.7	65.61	-.09	
	176	65.8	66.13	+.33	
	180	66.5	66.77	+.27	
	185	67.4	67.4	0	.189
80M	104	53.0	52.77	-.23	
	116	55.7	55.7	0	
	128	57.5	57.92	+.42	
	133	58.5	58.66	+.16	
	140	59.7	59.62	-.08	
	145	60.1	60.35	+.25	
	149	61.0	61.01	+.01	

APPENDIX H--1 (Continued)

Case No.	Age	Measured Inches	Predicted Inches	Deviations	Average Deviation
80M con't.	152	61.6	61.6	0	
	157	62.5	62.68	+.18	
	161	63.5	63.58	+.08	
	164	63.7	64.26	+.56	
	168	65.1	65.18	+.08	
	173	66.2	66.2	0	.158
83M	89	46.6	46.6	0	
	93	48.0	47.58	-.42	
	101	49.0	49.35	+.35	
	113	51.6	51.64	+.04	
	125	53.4	53.50	+.10	
	129	54.4	54.06	-.34	
	137	55.0	55.06	+.06	
	141	56.1	55.58	-.52	
	149	57.0	56.74	-.26	
	153	57.4	57.4	0	
	158	58.6	58.33	-.27	
	161	58.6	58.96	+.38	
	165	59.4	59.84	+.44	
	170	61.0	60.98	-.02	
	173	61.7	61.66	-.04	
	177	61.7	62.51	+.81	
	182	63.0	63.59	+.59	
	185	64.2	64.20	0	
	189	65.2	64.95	-.25	
	194	66.0	65.78	-.22	.256
87M	112	52.2	52.2	0	
	124	54.6	54.91	+.31	
	136	57.0	57.02	+.02	
	140	57.7	57.66	+.16	
	148	58.7	58.75	+.05	
	150	60.0	59.04	-.96	
	157	60.5	60.17	-.33	
	160	60.7	60.7	0	
	164	62.0	61.47	-.53	
	169	62.5	62.57	+.07	
	172	63.2	63.2	0	
	176	64.0	63.97	-.03	
	181	65.6	64.77	-.83	.253
110M	100	51.2	51.15	-.05	
	112	53.7	53.7	0	
	124	55.2	55.56	+.36	

APPENDIX H--1 (Continued)

Case No.	Age	Measured Inches	Predicted Inches	Deviations	Average Deviation
110M con't.	136	57.6	56.88	-.12	
	148	57.8	58.00	+.20	
	152	58.2	58.53	+.33	
	160	60.0	60.06	+.06	
	164	61.1	61.1	0	
	169	62.4	62.56	+.16	
	172	62.8	63.43	+.63	
	176	64.6	64.6	0	
	181	66.4	65.97	-.43	.195
115M	101	50.7	50.62	-.08	
	105	51.6	51.6	0	
	113	53	53.38	+.38	
	125	55.6	55.68	+.08	
	137	57.5	57.62	+.12	
	141	58.5	58.23	-.27	
	149	59.7	59.7	0	
	153	61.0	60.54	-.46	
	158	61.2	61.62	+.42	
	161	61.6	62.29	+.69	
	165	63.2	63.2	0	
	170	64.7	64.32	-.38	.240
129M	97	46.0	46.0	0	
	109	48.0	48.14	+.14	
	113	48.8	48.79	-.01	
	121	49.7	49.97	+.27	
	133	51.7	51.51	-.19	
	145	52.8	52.83	+.03	
	149	53.4	53.29	-.11	
	157	54.8	54.51	-.29	
	161	55.4	55.4	0	
	166	56.6	56.7	+.10	
	169	57.2	57.59	+.39	
	173	58.7	58.76	+.06	
	178	60.2	60.2	0	.122
136M	109	51.7	51.7	0	
	121	54.0	54.37	+.37	
	133	56.5	56.5	0	
	138	57.3	57.32	+.02	
	145	58.7	58.67	-.03	
	150	60.1	60.1	0	
	154	61.5	61.43	-.07	
	157	62.7	62.47	-.23	

APPENDIX H--1 (Continued)

Case No.	Age	Measured Inches	Predicted Inches	Deviations	Average Deviation
136M con't.	162	64.0	64.04	+.04	
	166	65.1	65.11	+.01	
	169	66.0	65.83	-.17	
	173	66.6	66.6	0	
	178	67.1	67.38	+.28	.094
162M	113	56.2	56.2	0	
	125	58.7	59.23	+.53	
	137	61.5	61.43	-.07	
	141	62.0	62.0	0	
	149	63.0	63.02	+.02	
	153	64.7	63.72	-.98	
	161	65.7	65.7	0	
	165	67.0	67.0	0	.200
163M	120	56.7	56.71	+.01	
	132	59.7	59.7	0	
	137	60.5	60.72	+.22	
	144	62.0	61.95	-.05	
	149	62.7	62.74	+.04	
	153	63.5	63.49	-.01	
	156	64.2	64.2	0	
	161	65.5	65.75	+.25	
	165	67.2	67.15	-.05	
	166	67.5	67.55	+.05	
	172	68.6	69.47	+.87	
	177	70.8	70.8	0	.129
164M	96	48.1	48.1	0	
	108	50.6	50.75	+.15	
	113	51.5	51.73	+.23	
	120	52.5	52.95	+.45	
	125	53.1	53.68	+.58	
	129	54.3	54.26	-.04	
	132	54.5	54.66	+.16	
	137	55.2	55.28	+.08	
	144	56.0	56.14	+.14	
	149	56.6	56.80	+.20	
	153	57.7	57.25	-.45	
	156	57.7	57.7	0	
	161	58.5	58.44	-.06	
	165	58.6	59.09	+.49	
	168	59.6	59.62	+.02	
	173	60.5	60.5	0	
	177	61.2	61.16	-.04	.182

APPENDIX H--1 (Continued)

Case No.	Age	Measured Inches	Predicted Inches	Deviations	Average Deviation
167M	100	49.7	49.7	0	
	112	52.4	52.32	-.08	
	117	52.7	53.13	+.43	
	124	54.3	54.14	-.16	
	129	54.7	54.84	+.14	
	133	55.0	55.49	+.49	
	136	56.2	56.08	-.12	
	141	57.2	57.2	0	
	148	59.0	59.08	+.08	
	153	60.1	60.46	+.36	
	157	61.7	61.49	-.21	
	160	62.1	62.21	+.11	
	165	63.5	63.24	-.26	
	169	63.8	63.94	+.14	
	172	64.5	64.35	-.15	
	177	65.1	64.98	-.12	
	181	65.1	65.37	+.27	.184
171M	101	49.0	49.0	0	
	113	51.5	51.9	+.40	
	125	53.5	53.46	-.04	
	137	55.6	55.68	+.08	
	142	56.2	56.2	0	
	147	57.1	56.68	-.42	
	154	57.6	57.6	0	
	158	58.7	57.89	-.81	
	161	59.0	59.01	+.01	
	166	60.1	60.32	+.22	
	170	61.5	61.38	-.12	
	173	62.2	62.2	0	
	177	62.7	63.16	+.46	
	182	64.5	64.23	-.27	.202
176M	97	50.0	50.0	0	
	109	53.4	52.08	-1.32	
	133	55.1	55.30	+.20	
	138	55.3	55.80	+.50	
	145	56.5	56.51	+.01	
	150	57.0	57.0	0	
	154	57.0	57.4	+.40	
	157	57.7	57.7	0	
	162	58.0	58.25	+.25	
	166	58.8	58.8	0	
	169	59.2	59.2	0	
	174	60.0	59.91	-.09	

APPENDIX H-1--(Continued)

Case No.	Age	Measured Inches	Predicted Inches	Deviations	Average Deviation
176M	178	60.0	60.5	+.50	
con't.	179	60.8	60.65	-.15	.244
195M	91	49.7	49.14	-.54	
	103	52.6	52.6	0	
	110	54.0	54.28	+.28	
	122	56.7	56.7	0	
	134	58.7	58.73	+.03	
	146	61.6	61.6	0	
	158	65.5	65.33	-.17	
	163	66.6	66.55	-.05	
	167	67.4	67.33	-.07	
	170	67.7	67.8	+.10	
	175	68.7	68.46	-.24	
	179	69.0	68.84	-.16	
	182	69.1	69.1	0	
	187	69.4	69.45	+.05	
	191	69.6	69.67	+.07	.117

Boys' Total Average Deviation .182

Boys' Range of Deviations .094 -- .256

APPENDIX H--2

DEVIATION OF MEASURED HEIGHT SCORES FROM PREDICTED HEIGHT SCORES

Case No.	Age	Measured	Predicted	Deviations	Average Deviation
52F	102	52.0	51.0	-1.00	
	107	52.4	52.4	0	
	114	54.0	54.05	+.05	
	119	55.0	55.02	+.02	
	123	56.0	55.74	+.26	
	126	56.2	56.27	+.07	
	131	57.2	57.2	0	
	135	59.0	58.11	-.89	
	138	59.3	58.87	-.43	
	143	60.2	60.15	-.05	
	147	62.0	61.11	-.89	
	150	62.2	61.74	-.46	
	155	62.7	62.65	-.05	
	159	63.2	63.2	0	
	162	63.6	63.59	-.01	
	167	64.0	64.03	+.03	
	171	64.0	64.33	+.33	.267
55F	105	51.4	50.13	-1.27	
	112	52.6	52.6	0	
	117	54.0	54.0	0	
	121	55.0	54.94	-.06	
	124	55.6	55.6	0	
	129	56.4	56.64	+.24	
	133	57.6	57.6	0	
	136	58.3	58.45	+.15	
	141	60.2	59.96	+.24	
	145	61.7	61.2	-.50	
	148	62.0	62.11	+.11	
	153	63.8	63.40	-.40	
	157	63.8	64.27	+.47	
	160	64.5	64.79	+.29	
	165	65.5	65.5	0	
	169	66.0	65.93	-.07	.238
58F	91	47.6	47.6	0	
	103	50.2	50.37	+.17	
	115	52.4	52.57	+.17	
	120	53.5	53.29	-.21	
	127	54.2	54.25	+.05	
	139	56.0	55.83	-.17	
	144	56.6	56.6	0	

APPENDIX H--2 (Continued)

Case No.	Age	Measured Inches	Predicted Inches	Deviations	Average Deviation
58F con't.	151	57.4	57.78	+.38	
	156	58.7	58.73	+.03	
	160	59.5	59.51	+.01	
	163	60.2	60.13	-.07	
	168	61.0	61.15	+.15	
	172	61.7	61.94	+.24	
	175	62.5	62.49	-.01	
	180	63.4	63.36	-.04	
	184	64.0	64.0	0	.106
59F	109	48.6	48.6	0	
	114	49.4	49.41	+.01	
	121	50.0	50.45	+.45	
	126	51.0	51.15	+.15	
	130	51.0	51.65	+.65	
	133	52.0	52.02	+.02	
	138	52.6	52.62	+.02	
	142	53.0	53.15	+.15	
	145	53.6	53.56	-.04	
	150	54.5	54.40	-.10	
	154	55.2	55.2	0	
	157	55.7	55.84	+.14	
	162	57.7	57.01	-.69	
	166	58.0	57.94	-.06	
	169	58.5	58.58	+.08	
	174	59.6	59.6	0	
	178	61.1	60.4	-.70	.192
62F	100	51.6	51.6	0	
	112	54.0	54.0	0	
	117	55.0	54.72	-.28	
	124	55.6	55.73	+.13	
	129	56.3	56.49	+.19	
	133	57.2	57.2	0	
	136	58.2	57.83	-.37	
	141	59.0	59.0	0	
	148	60.0	60.65	+.65	
	153	61.2	61.79	+.59	
	157	62.2	62.56	+.36	
	160	64.2	63.13	-1.07	
	165	64.2	63.94	-.26	
	169	64.4	64.4	0	
	172	64.4	64.75	+.35	
	177	65.2	65.19	-.01	
	181	65.2	65.48	+.28	.267

APPENDIX H--2 (Continued)

Case No.	Age	Measured Inches	Predicted Inches	Deviations	Average Deviation
64F	90	45.6	45.6	0	
	97	50.1	48.91	-1.19	
	109	53.0	52.88	-.12	
	121	55.2	55.2	0	
	126	56.0	55.90	-.10	
	133	57.2	56.76	-.44	
	138	58.0	57.96	-.04	
	142	59.6	59.32	-.28	
	145	60.4	60.4	0	
	150	61.6	61.79	+.19	
	154	62.4	62.61	+.21	
	157	63.0	63.0	0	
	162	63.5	63.48	-.02	
	166	63.7	63.71	+.01	
	169	63.8	63.83	+.03	
	174	63.6	63.97	+.37	
	178	63.8	64.04	+.24	
	181	63.8	64.08	+.28	.196
65F	93	50.3	50.3	0	
	105	52.4	52.53	+.13	
	110	53.0	53.29	+.29	
	117	54.2	54.2	0	
	122	54.4	54.84	+.44	
	126	56.0	55.48	-.52	
	129	56.2	56.11	-.09	
	134	57.4	57.37	-.03	
	141	59.1	59.1	0	
	146	60.0	60.09	+.09	
	150	61.0	60.67	-.33	
	153	61.1	61.06	-.04	
	158	62.0	61.5	-.50	
	162	61.5	61.81	+.31	
	165	62.0	62.0	0	
	170	62.2	62.19	-.01	
	174	62.4	62.35	-.05	.166
69F	86	49.0	49.0	0	
	98	52.0	52.29	+.29	
	110	54.6	54.91	+.31	
	114	55.6	55.68	+.08	
	122	57.0	57.05	+.05	
	134	59.4	59.33	-.07	
	138	60.4	60.24	-.16	
	143	61.4	61.4	0	

APPENDIX H--2 (Continued)

Case No.	Age	Measured Inches	Predicted Inches	Deviations	Average Deviation
69F	146	62.0	62.12	+.12	
con't.	150	63.2	62.95	-.25	
	155	63.6	63.93	+.33	
	158	64.2	64.43	+.23	
	162	65.2	65.04	-.16	.158
71F	91	50.2	50.2	0	
	103	52.6	52.94	+.34	
	115	55.1	55.04	-.06	
	127	56.6	57.17	+.57	
	139	60.0	60.01	+.01	
	144	60.4	61.16	+.76	
	148	62.0	62.0	0	
	151	63.0	62.56	-.44	
	156	63.4	63.36	-.04	
	160	64.2	63.86	-.34	
	163	64.2	64.2	0	
	167	64.7	64.56	-.14	
	172	65.0	64.97	-.03	
	175	65.0	65.15	+.15	.206
78F	76	45.6	45.9	+.30	
	81	47.0	47.0	0	
	85	48.4	47.82	-.58	
	100	50.6	50.63	+.03	
	112	52.3	52.43	+.13	
	117	53.1	53.1	0	
	124	54.4	54.03	-.37	
	136	57.0	56.20	-.80	
	141	57.4	57.49	+.09	
	145	58.6	58.6	0	
	148	59.4	59.38	-.02	
	153	60.6	60.54	-.06	
	157	61.2	61.33	+.13	
	160	61.6	61.86	+.26	
	164	62.7	62.44	-.26	
	169	63.0	63.03	+.03	
	172	63.2	63.35	+.15	
	176	63.7	63.70	0	
	181	63.8	64.07	+.27	.183
80F	88	42.0	42.0	0	
	100	45.4	45.39	-.01	
	109	47.1	47.1	0	
	117	48.0	48.20	+.20	

APPENDIX H--2 (Continued)

Case No.	Age	Measured Inches	Predicted Inches	Deviations	Average Deviation
80F con't.	124	49.4	48.93	-.47	
	136	51.1	50.66	-.44	
	141	52.0	52.0	0	
	145	53.0	53.25	+.25	
	148	54.4	54.24	-.16	
	153	55.6	55.82	+.22	
	157	57.2	56.92	-.28	
	160	57.7	57.62	-.08	
	164	58.5	58.42	-.08	
	169	59.2	59.2	0	
	176	60.2	60.05	-.15	
	181	60.2	60.32	+.12	.154
84F	106	50.7	50.8	+.10	
	111	52.2	52.2	0	
	118	53.7	53.75	+.05	
	130	55.7	56.04	+.34	
	135	56.2	57.25	+1.05	
	139	58.0	58.35	+.35	
	142	59.2	59.2	0	
	147	60.7	60.49	-.21	
	151	61.2	61.37	+.17	
	154	61.7	61.94	+.24	
	159	62.7	62.7	0	
	163	63.5	63.15	-.35	
	166	63.5	63.4	-.10	
	171	63.5	63.75	+.25	
	175	63.7	63.97	+.27	.232
97F	111	51.1	51.1	0	
	123	54.0	54.0	0	
	135	56.0	56.0	0	
	139	56.5	56.51	+.01	
	147	58.7	57.79	-.91	
	151	58.7	58.7	0	
	156	59.7	59.79	+.09	
	159	60.0	60.34	+.34	
	163	61.0	60.96	-.04	
	168	61.5	61.5	0	.140
105F	109	49.5	49.5	0	
	113	50.5	50.12	-.38	
	121	51.2	51.28	+.08	
	133	53.5	53.5	0	
	145	56.5	56.63	+.13	

APPENDIX H--2 (Continued)

Case No.	Age	Measured Inches	Predicted Inches	Deviations	Average Deviation
105F con't.	149	58.0	57.68	-.32	
	157	57.6	59.47	+1.87	
	161	60.2	60.16	-.04	
	166	61.0	60.93	-.07	
	169	61.2	61.30	+.10	
	173	61.7	61.7	0	
	178	61.7	62.14	+.44	.283
118F	94	47.7	45.65	-.05	
	106	49.2	49.2	0	
	118	51.0	51.65	+.65	
	130	53.5	53.58	+.08	
	142	55.7	55.7	0	
	147	57.0	55.26	+.26	
	151	59.2	58.56	-.64	
	154	59.2	59.53	+.33	
	159	60.5	60.86	+.36	
	163	61.7	61.7	0	
	166	62.2	62.2	0	
	171	62.5	62.9	+.40	
	175	63.2	63.28	+.08	.219
189F	108	49.7	49.7	0	
	120	52.5	52.68	+.18	
	124	53.5	53.52	+.02	
	132	55.0	55.08	+.08	
	144	57.7	57.7	0	
	160	62.0	60.84	-1.16	
	168	63.2	63.49	+.29	
	172	64.2	64.2	0	
	177	65.2	64.99	+.21	
	180	65.2	65.37	+.17	
	184	66.0	65.83	-.17	
	189	66.2	66.28	+.08	.197
190F	87	45.2	45.18	-.02	
	92	46.0	46.0	0	
	99	47.4	48.36	+.76	
	111	50.6	50.94	+.34	
	123	53.0	53.0	0	
	135	56.0	54.65	-1.35	
	147	58.2	58.2	0	
	152	59.2	59.79	+.59	
	156	60.7	60.7	0	
	159	61.0	61.24	+.24	

Case
No

190
con

22

APPENDIX H--2 (Continued)

Case No.	Age	Measured Inches	Predicted Inches	Deviations	Average Deviation
190F con't.	164	62.0	61.90	-.10	
	168	62.2	62.35	+.15	
	171	62.5	62.5	0	
	175	63.0	62.73	-.27	
	180	63.0	63.0	0	.255
227F	80	47.0	46.81	-.19	
	88	49.0	49.0	0	
	100	51.4	51.77	+.34	
	104	52.7	52.58	-.12	
	112	54.0	54.01	+.01	
	124	56.5	56.17	-.33	
	136	59.0	59.0	0	
	140	60.5	60.13	-.37	
	148	62.0	62.10	+.10	
	152	63.0	62.96	-.04	
	157	64.2	63.87	-.33	
	160	64.5	64.37	-.13	
	164	65.2	65.10	-.10	
	169	65.5	65.5	0	.147

Girls' Total Average Deviation .200

Girls' Range of Deviations .106 -- .283

APPENDIX H--3

DEVIATION OF PREDICTED WEIGHT SCORE FROM ACTUAL WEIGHT SCORE

Case No.	Age	Measured Pounds	Predicted Pounds	Deviations	Average Deviation
27M	86	55.3	55.3	0	
	97	65.0	61.61	-3.39	
	109	63.3	68.08	+4.78	
	121	74.2	74.2	0	
	133	82.2	79.85	-2.35	
	145	85.0	85.12	+ .12	
	157	99.0	99.0	0	
	169	125.5	125.5	0	
	175	135.7	135.75	+ .05	1.188
31M	126	56.2	56.2	0	
	138	61.0	61.75	+ .75	
	150	67.0	67.0	0	
	162	73.0	73.0	0	
	168	78.5	78.39	- .11	
	174	84.5	84.5	0	.143
42M	71	47.2	47.2	0	
	83	53.0	54.02	+1.02	
	95	61.2	59.94	-1.26	
	108	65.2	65.33	+ .13	
	119	69.1	69.1	0	
	131	77.1	72.79	-8.95	
	143	82.1	82.1	0	
	155	102.2	102.18	- .02	
	167	112.7	112.7	0	1.264
44M	80	45.2	45.2	0	
	92	52.2	52.73	+ .53	
	104	60.0	59.08	- .92	
	116	64.2	64.23	+ .03	
	128	68.3	68.45	+ .15	
	140	74.3	74.3	0	
	152	87.1	87.11	+ .01	
	164	100.0	105.31	+5.31	
	176	122.2	122.2	0	.772
45M	90	58.1	58.1	0	
	102	66.1	66.47	+ .37	
	114	74.2	74.2	0	
	126	81.1	81.06	- .04	
	138	94.3	88.77	-5.57	

APPENDIX H--3 (Continued)

Case No.	Age	Measured Pounds	Predicted Pounds	Deviations	Average Deviation
45M con't.	150	105.3	105.3	0	
	162	118.7	124.73	-6.03	
	174	138.2	138.2	0	1.500
50M	86	42.0	41.69	- .36	
	98	47.0	47.0	0	
	110	52.2	52.2	0	
	122	58.3	57.12	-1.18	
	134	61.1	61.85	+ .75	
	146	66.2	67.84	+1.64	
	158	75.2	75.2	0	
	170	92.5	92.51	+ .01	
	182	108.0	108.0	0	.440
51M	95	53.0	53.0	0	
	107	66.3	62.4	+3.60	
	119	71.3	70.5	- .80	
	131	77.2	77.2	0	
	143	83.3	83.25	- .05	
	155	97.2	97.2	0	
	167	112.5	117.09	+4.59	
	179	130.2	130.2	0	1.130
55M	88	52.2	52.2	0	
	100	60.3	60.44	+ .14	
	112	68.0	67.89	- .02	
	124	75.0	75.01	+ .01	
	136	84.2	82.11	-2.09	
	148	95.0	95.0	0	
	154	106.5	104.90	-1.60	
	160	111.0	116.05	+5.05	
	166	127.2	127.2	0	.990
61M	101	55.0	55.0	0	
	113	62.1	62.04	- .06	
	125	68.1	68.53	+ .43	
	137	74.3	74.3	0	
	149	80.3	80.3	0	
	161	89.3	89.4	+ .10	
	167	95.5	95.5	0	
	173	101.5	102.21	+ .71	
	179	110.0	108.89	-1.11	.268
65M	109	54.1	54.1	0	
	121	60.0	60.69	+ .69	

APPENDIX H--3 (Continued)

Case No.	Age	Measured Pounds	Predicted Pounds	Deviations	Average Deviation
65M	133	66.2	67.0	+ .80	
cont.	145	73.0	73.01	+ .01	
	157	79.1	80.91	+1.81	
	163	89.0	89.0	0	
	169	100.0	99.22	- .78	
	175	108.2	109.13	+ .93	
	181	117.1	117.02	- .08	
	187	123.0	123.0	0	.510
71M	103	55.0	55.0	0	
	115	64.7	64.62	- .08	
	127	72.0	72.22	+ .22	
	139	77.0	79.99	+2.99	
	151	91.0	91.0	0	
	163	104.1	104.03	- .07	
	175	115.7	115.7	0	.480
77M	117	69.7	69.7	0	
	128	77.2	76.82	- .18	
	140	80.2	82.82	+2.62	
	152	87.0	88.05	+1.05	
	158	91.7	91.11	- .59	
	164	94.7	94.7	0	
	170	97.5	98.76	+1.26	
	176	103.1	103.1	0	
	182	109.0	107.44	-1.56	.807
80M	105	68.2	68.2	0	
	117	76.5	76.43	- .07	
	128	80.5	81.89	+1.39	
	140	86.2	86.39	+ .19	
	152	95.7	95.7	0	
	158	104.7	104.65	- .05	
	164	109.0	114.06	+5.06	
	170	122.0	122.0	0	.845
83M	101	52.3	52.3	0	
	114	60.0	59.95	- .05	
	125	63.2	65.65	+2.45	
	137	71.0	71.0	0	
	149	75.0	75.53	+ .53	
	161	80.0	79.40	- .60	
	173	89.3	89.3	0	
	179	100.7	100.06	- .64	
	185	105.7	110.99	+5.29	
	191	119.5	119.5	0	.956

APPENDIX H--3 (Continued)

Case No.	Age	Measured Pounds	Predicted Pounds	Deviations	Average Deviation
87M	113	63.0	63.0	0	
	124	70.0	72.56	+2.56	
	136	81.0	81.01	+ .01	
	148	87.5	87.54	+ .04	
	154	97.0	95.59	-1.41	
	160	95.2	99.86	+4.66	
	166	110.0	110.0	0	
	172	120.0	118.25	-1.75	
	178	123.5	123.5	0	1.159
110M	112	62.2	62.2	0	
	124	67.5	70.33	+2.83	
	136	78.0	78.0	0	
	148	82.0	84.89	+2.89	
	160	91.2	91.75	+ .55	
	166	97.2	97.2	0	
	172	105.2	105.79	+ .59	
	178	116.7	116.7	0	.856
115M	89	50.0	50.0	0	
	101	56.5	56.10	- .40	
	113	61.2	61.66	+ .46	
	125	66.7	66.7	0	
	137	72.0	71.15	- .85	
	149	79.1	77.19	-1.91	
	155	82.5	82.5	0	
	161	89.2	89.54	+ .34	
	167	97.5	97.5	0	.440
129M	97	53.0	53.0	0	
	109	58.0	58.19	+ .19	
	122	63.5	63.61	+ .11	
	133	69.0	69.0	0	
	146	77.2	77.2	0	
	157	83.1	84.28	+1.18	
	169	90.5	90.49	- .01	.213
136M	110	55.0	55.0	0	
	121	62.2	63.88	+1.68	
	133	72.0	72.0	0	
	145	78.5	79.27	+ .77	
	151	89.1	85.44	-3.66	
	157	95.0	95.0	0	
	163	106.0	106.0	0	
	169	114.0	115.84	+1.84	
	175	125.0	123.49	-1.51	1.051

APPENDIX H--3(Continued)

Case No.	Age	Measured Pounds	Predicted Pounds	Deviations	Average Deviation
162M	101	62.0	62.0	0	
	115	70.0	73.92	+3.92	
	125	80.0	80.0	0	
	137	89.5	88.1	-1.39	
	149	93.7	95.10	+1.40	
	155	102.5	102.5	0	
	161	108.7	110.88	+2.18	
	167	117.7	117.7	0	1.111
163M	96	62.2	62.2	0	
	109	71.2	74.41	+3.21	
	120	83.0	83.03	+ .03	
	132	90.7	90.73	+ .03	
	144	98.5	98.5	0	
	150	106.7	104.85	-1.85	
	156	112.0	113.75	+1.75	
	162	127.5	124.54	-2.96	
	168	132.1	132.53	+ .43	
	174	146.2	146.2	0	1.026
164M	84	44.1	44.1	0	
	96	53.0	50.10	-2.90	
	108	56.2	56.2	0	
	120	59.2	62.21	+3.01	
	132	68.2	68.3	+ .10	
	144	74.0	74.13	+ .13	
	156	82.5	82.5	0	
	162	92.0	88.92	-3.08	
	168	95.0	95.03	+ .03	
	174	100.0	100.0	0	.925
167M	88	52.0	52.0	0	
	100	60.1	60.14	+ .04	
	113	66.0	67.64	+1.64	
	124	73.0	73.19	+ .19	
	136	84.3	81.53	-2.77	
	148	99.0	99.0	0	
	160	123.5	123.52	+ .02	
	172	146.2	146.2	0	.583
171M	101	53.0	53.0	0	
	114	61.2	61.1	- .10	
	125	67.0	67.2	+ .20	
	137	75.7	73.0	-2.70	
	149	78.0	78.33	+ .33	

APPENDIX H--3 (Continued)

Case No.	Age	Measured Pounds	Predicted Pounds	Deviations	Average Deviation
171M	161	88.2	87.62	- .58	
con't.	167	94.7	95.25	+ .55	
	173	103.1	103.78	+ .68	
	179	113.0	111.94	-1.06	.689
176M	85	45.1	45.1	0	
	97	49.0	49.5	+ .50	
	109	60.0	53.60	-6.40	
	133	61.0	61.01	+ .01	
	145	64.3	64.53	+ .23	
	157	69.2	69.2	0	
	169	75.5	75.53	+ .03	
	181	82.7	82.7	0	.896
195M	99	64.0	63.36	- .64	
	110	70.7	70.7	0	
	123	75.7	78.32	+2.62	
	134	86.2	84.10	-2.10	
	146	95.2	95.2	0	
	158	112.1	112.95	+ .85	
	170	128.0	127.45	- .55	
	182	136.0	136.0	0	.845

Boys' Total Average Deviation .811

Boys' Range of Deviations .143 -- 1.500

APPENDIX H--4

DEVIATION OF PREDICTED WEIGHT SCORE FROM ACTUAL WEIGHT SCORE

Case No.	Age	Measured Pounds	Predicted Pounds	Deviations	Average Deviation
52F	91	56.2	56.2	0	
	102	60.1	60.11	+ .01	
	114	65.0	65.69	+ .69	
	126	75.0	75.0	0	
	138	90.3	90.32	+ .02	
	150	106.2	106.2	0	
	162	118.2	118.18	- .02	.106
55F	76	40.3	40.3	0	
	101	52.0	51.91	- .09	
	112	55.1	55.41	+ .31	
	124	61.2	61.2	0	
	136	73.3	72.79	- .51	
	148	87.0	87.51	+ .51	
	160	100.5	100.5	0	.203
58F	91	49.2	49.2	0	
	103	57.3	57.24	- .06	
	115	62.3	63.17	+ .87	
	127	67.1	67.37	+ .27	
	139	71.0	70.25	- .75	
	151	72.2	72.96	+ .76	
	157	83.5	78.77	-4.73	
	163	89.2	89.2	0	
	169	98.7	98.99	+ .27	
	175	106.2	105.45	- .75	
	181	109.2	109.2	0	.769
59F	110	56.2	56.2	0	
	115	59.2	59.2	0	
	121	58.3	62.2	+3.90	
	125	64.0	64.01	+ .01	
	133	65.3	67.28	+1.98	
	139	69.1	69.93	+ .83	
	145	71.0	73.60	+2.60	
	151	78.5	78.5	0	
	157	82.0	84.12	+2.12	
	163	90.2	89.99	- .21	
	169	93.2	95.38	+2.18	
	175	100.2	100.2	0	1.153

APPENDIX H--4 (Continued)

Case No.	Age	Measured Pounds	Predicted Pounds	Deviations	Average Deviation
62F	88	51.1	51.1	0	
	100	60.1	60.1	0	
	112	62.3	66.94	+4.64	
	124	72.0	72.37	+ .37	
	136	83.2	83.2	0	
	148	100.0	102.06	+2.06	
	160	119.0	116.95	-2.05	
	172	125.0	125.0	0	1.140
64F	97	70.1	70.1	0	
	109	93.0	89.82	-3.18	
	121	100.0	105.84	+5.84	
	133	118.1	118.1	0	
	145	127.0	132.5	+5.50	
	157	169.1	169.1	0	
	169	193.0	192.68	- .32	
	181	201.5	201.50	0	1.855
65F	81	54.3	54.3	0	
	93	58.1	58.29	+ .19	
	105	62.2	62.51	+ .31	
	117	68.3	68.41	+ .11	
	129	78.0	78.0	0	
	141	94.1	90.01	-4.09	
	153	99.7	101.69	+1.99	
	165	111.2	111.2	0	.836
69F	98	62.2	59.54	-2.66	
	110	73.0	73.0	0	
	122	81.0	84.67	+3.67	
	134	94.3	94.3	0	
	146	102.3	102.3	0	
	158	122.3	122.42	+ .12	
	170	140.7	140.7	0	.921
71F	91	51.3	51.3	0	
	103	56.3	56.68	+ .38	
	115	61.6	61.22	- .38	
	127	65.0	65.35	+ .35	
	139	72.3	75.04	+6.99	
	145	88.3	88.3	0	
	151	94.3	94.7	+ .40	
	157	99.0	98.67	- .33	
	163	101.0	101.12	+ .12	
	169	104.7	102.64	-2.06	
	175	103.7	103.7	0	1.001

APPENDIX H--4 (Continued)

Case No.	Age	Measured Pounds	Predicted Pounds	Deviations	Average Deviation
78F	88	51.2	50.05	-1.15	
	101	58.3	58.3	0	
	112	64.0	64.79	+ .79	
	124	71.2	71.28	+ .08	
	136	77.0	77.88	+ .88	
	148	89.3	89.3	0	
	160	105.0	105.84	+ .84	
	172	119.70	119.70	0	.468
80F	76	32.2	31.75	- .45	
	88	36.0	36.0	0	
	100	37.4	40.10	+2.70	
	112	44.1	44.06	- .04	
	124	48.0	47.79	- .21	
	136	51.3	52.34	+1.04	
	142	57.3	57.21	- .09	
	148	64.2	65.0	+ .80	
	154	74.2	74.2	0	
	160	78.0	83.08	+5.08	
	166	92.0	90.55	-1.45	
	178	100.7	100.7	0	.988
84F	70	43.5	41.79	-1.71	
	82	47.5	47.5	0	
	94	49.0	53.13	+4.13	
	106	58.2	58.49	+ .29	
	118	63.5	63.5	0	
	130	70.5	70.5	0	
	142	87.7	88.32	+ .62	
	154	104.0	104.0	0	
	166	112.2	112.13	- .07	.758
97F	99	49.0	49.0	0	
	112	53.5	59.97	+6.47	
	123	67.7	67.73	+ .03	
	135	75.0	74.50	- .50	
	147	79.7	82.25	+2.55	
	153	91.0	91.0	0	
	159	102.5	98.12	-4.38	
	165	102.2	102.2	0	1.741
105F	89	50.5	50.5	0	
	109	51.7	54.20	+2.50	
	115	55.0	55.54	+ .54	
	122	56.0	58.03	+2.03	

APPENDIX H--4 (Continued)

Case No.	Age	Measured Pounds	Predicted Pounds	Deviations	Average Deviation
105F con't.	133	65.5	65.5	0	
	145	79.3	78.76	- .54	
	157	93.0	93.67	+ .67	
	169	106.7	106.7	0	.785
118F	107	48.5	48.5	0	
	118	56.7	56.7	0	
	130	63.5	64.4	+ .90	
	143	72.0	71.27	- .73	
	154	81.7	81.7	0	
	160	91.7	91.69	- .01	
	166	103.0	100.4	-2.60	
	172	106.5	106.5	0	.530
189F	109	48.2	48.2	0	
	120	56.5	56.48	- .02	
	133	63.5	65.33	+1.83	
	144	71.7	71.72	+ .02	
	159	81.5	81.5	0	
	168	88.2	91.0	+2.80	
	174	98.2	98.02	- .18	
	180	103.0	104.57	+1.57	
	186	110.2	110.2	0	.713
190F	99	53.5	53.5	0	
	112	60.7	62.13	+1.43	
	123	69.7	68.31	-1.39	
	135	74.0	74.32	+ .32	
	147	83.7	83.7	0	
	159	98.5	98.48	- .02	
	171	111.1	111.1	0	.451
227F	100	55.0	55.0	0	
	113	61.0	66.59	+5.59	
	124	75.2	75.21	+ .01	
	136	84.0	84.0	0	
	148	97.5	95.99	-1.51	
	154	101.0	102.9	+1.90	
	160	106.2	109.35	+3.15	
	166	115.0	115.0	0	1.520

Girl's Total Average Deviation .885

Girl's Range of Deviations .106 -- 1.855

APPENDIX I

CURVE OF CONSTANTS TABULATION

C.A. in Months	Boys				Girls			
	Measure		Per Cent of Total Maturity		Measure		Per Cent of Total Maturity	
	Height	Weight	Height	Weight	Height	Weight	Height	Weight
84	45.26	45.26	64.29	30.20	44.33	45.74	67.27	33.69
96	48.95	54.51	69.53	36.38	48.45	54.56	73.52	40.19
108	51.99	62.90	73.85	41.98	51.56	62.44	78.24	45.99
120	54.40	70.44	77.27	47.01	53.79	69.17	81.63	50.95
132	56.28	77.03	79.94	51.40	55.71	74.78	84.54	55.08
144	57.78	82.80	82.07	55.26	58.68	84.54	89.04	62.27
156	60.01	93.50	85.24	62.40	61.82	103.38	93.81	76.14
168	63.22	112.27	89.80	74.92	63.74	118.09	96.72	86.98
180	66.00	127.58	93.75	85.14	64.69	125.58	98.16	92.49
192	67.72	136.08	96.19	90.81	65.13	129.30	98.83	95.23
204	68.69	140.63	97.57	93.85	65.42	131.23	99.27	96.66
216	69.27	143.22	98.39	95.58	65.56	132.52	99.48	97.61
228	69.62	144.85	98.89	96.66	65.68	133.36	99.67	98.22
240	69.83	146.05	99.19	97.46	65.75	133.95	99.77	98.66
252	69.98	146.85	99.40	98.00	65.80	134.35	99.85	98.95
264	70.08	147.50	99.54	98.43	65.83	134.73	99.89	99.23
276	70.17	148.04	99.67	98.79	65.85	134.97	99.92	99.41
288	70.22	148.36	99.74	99.01	65.86	135.07	99.94	99.48
300	70.27	148.83	99.82	99.32	65.88	135.31	99.97	99.66
312	70.30	148.97	99.86	99.41	65.88	135.43	99.97	99.75
324	70.32	149.15	99.87	99.53	65.89	135.51	99.98	99.81
336	70.34	149.31	99.91	99.64	65.89	135.57	99.99	99.85
360	70.37	149.52	99.96	99.78	65.90	135.66	100.00	99.92
384	70.38	149.65	99.97	99.87	65.90	135.70	100.00	99.95
408	70.39	149.72	99.99	99.91	65.90	135.73	100.00	99.97