THE RELATIONSHIP BETWEEN GROWTH IN HEIGHT AND GROWTH IN WEIGHT

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THE RELATIONSHIP BETWEEN
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By

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CHAPTER I

INTRODUCTION

As far back as there are records, man has been shown to have been aware of the size of things.

Probably one of the first needs of primitive man for measurement was the sizing up of an opponent's strength. A rough estimation of height and weight were generally used to achieve this purpose.

Even primitive man has appeared to be conscious of the need for more refined measurement. Throughout history a variety of different techniques has been used.

One of the units used everywhere in the ancient world was the cubit.[1] The cubit, like most ancient units of measurement, was derived from the human body and defined as the distance from the elbow to the tip of the middle finger.[2] However, no unit of measure based on anything as variable as a part of the human body was exact enough for the needs of commerce even at that time. Therefore, men undertook to

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[1] "On Measurement is Founded the Whole Progress of Man", Sangamo Electric Company, Springfield, Illinois, p. 2.

[2] "Cubit" comes from the Latin "Cubitum", which means elbow.

establish standards. Measuring rods established the length of these cubits. The Egyptian Cubit was 20.6 inches, the Greek and Roman cubit was 26.8 inches, and the Persian cubit was 19.2 inches.[3]

This search for objectivity led to our present standardization of units of measurement. During the past century, numerous data have been collected through the use of such units, particularly with respect to the heights and weights of children.[4] The use of children probably is the result of at least a sub-conscious awareness of the importance of dealing with the growth process.

Many ways have been used to interpret the meaning of measurement results, but none of those which have been concerned with the units as such, have led to contributions of educational significance.

It was not until man began to look beyond the measurement units, to what he was measuring and why he was measuring it, that he became consciously aware of the growth process.

The next step in the refinement of measurement, therefore, became the discovery of a method for converting the specific man made units of measurement into the natural

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[3] Sangamo Electric Company, op. cit., p. 2.

[4] Howard V. Meredith, "Physical Growth of White Children," Society for Research in Child Development Monographs, Vol. 1, No. 2.

units of growth. Such a refinement was made available to education with the Courtis[5] adaptation of the Gompertz Function.

Statement of the Problem

If growth is a process of nature that is different from the specific units which man uses for measurement, and if the same growth process affects all measureable aspects, it would seem reasonable to expect to find a relationship between such growths as height and weight. It is assumed that the Courtis[6] adaptation of the Gompertz Function is in reality an accurate method for describing the natural growth process.

The purpose of this study, therefore, is to determine if a relationship can be discovered between height and weight through the use of this technique. The study is limited to girls in the preadolescent and adolescent cycles.

Importance of the Study

A great variety of material has been written supposedly dealing with the growth and development of children and a

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

[6] Ibid.

number of views and theories have been postulated to explain growth - many of which are conflicting. The most recent of the theories or schools of thought which purports to interpret human behavior is the organisimic concept.[7,8] This concept holds that all aspects of development, in respect to a life pattern, are related.[9] The recent works of Nally[10] and Kowitz[11] have demonstrated the validity of this aspect of the organismic concept through the use of the Courtis[12] Technique. Many have tried to explain the relationship between height and weight and other dimensions of growth through mass statistical technique without success.[13]

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[7]C. V. Millard, Child Growth and Development in the Elementary School Years, Boston: D. C. Heath and Co., 1951, p.4.

[8]W. C. Olson, Child Growth and Development, Boston: D. C. Heath, 1949, p. 16.

[9]Millard, op. cit., p. 4.

[10]Thomas Pomphert Francis 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.

[11]Gerald Thomas 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.

[12]Courtis, op. cit.

[13]Meredith, op. cit.

Increments have been used by some to show physical growth patterns with similar result.[14,15,16]

Although mathematical equations have been used to describe many aspects of growth, they have not yet been used to describe the relationship of height and weight.

Because of the success of Nally[17] and Kowitz,[18] in clearly showing other growth relationships with the Courtis approach, it will be used in this study to determine precisely the relationship between height and weight.

The Harvard Data[19] has been generally accepted as having valid measurements and since it has been analyzed by other measures it has been selected for use in this study.

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[14]Walter F. Dearborn and John W.M. Rothney, Predicting the Child's Development, Cambridge, Mass.: Sci-Art, 1941, pp.140-149.

[15]Wilton Marion, "A Handbook of the Measurement and Interpretation of Height and Weight in the Growing Child," Monographs of the Society for Research in Child Development, Vol. XIII, Serial No. 48, 1948, p. 38.

[16]Frank K. Shuttleworth, "The Adolescent Period: Graphic Atlas", Monographs of the Society for Research in Child Development, Vol. XIV, Serial No. 49, No. 1, 1949, Fig. 34 and 38.

[17]Nally, op. cit.

[18]Kowitz, op. cit.

[19]Dearborn and Rothney, Predicting the Child's Development, op. cit.

Definition of Terms

1. Development: "The progress towards maturity brought about in an immature organism by the action of appropriate environmental forces under constant conditions."[20] In actual practice, growth, development and maturation are used interchangeable depending upon the emphasis desired."[21]

2. Growth Cycle: Progress toward a specific state of condition made by an immature organism, other things being equal.[22]

3. The Gompertz function: $y = ke^{ce^{at}}$ 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.

4. Growth Constants: Maximum, rate, and incipiency.

5. Maximum: The ultimate state or condition within a specific cycle.

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[20] Stuart A. Courtis, Towards a Science of Education, Ann Arbor: Edwards Bros., 1951, p. 9.

[21] Stuart A. Courtis, Maturation Units and How to Use Them, Ann Arbor: Edwards Brow., 1950, p. 22.

[22] Nally, op. cit.

6. Rate: Constant progress toward a maximum expressed in isochrons.

7. Incipiency: Magnitude at the beginning of a period of maturation and is constant throughout the growth cycle.

8. Isochron: One percent of the total time required for a growth curve to change from a development of 0.000000189 percent to a development of 99.90917 percent.

CHAPTER II

REVIEW OF THE LITERATURE

Much has been written about the relationship of height and weight. Therefore, only a brief overview of the literature will be attempted.

Some of the earlier work dealt with the correlation of height with weight. A positive correlation was usually the result.[23] Such work showed that people who were taller were also usually heavier. This aspect of the correlations studies proved of little educational value.

However, the attempts of these investigators to describe body size contributed to our knowledge of measurement. The difficulty of measurement was traced, among other factors, to the variation in height and weight due to time of day, human factors related to individual patterns and techniques, and inaccurate instruments. A great deal has been done to eliminate such problems, but even in the measurement of height and weight there is still much that needs attention.

Several investigators have succeeded in developing generalized categories identified by the term, body build,

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[23] J. A. Harris, C.M. Jackson, D. G. Paterson, R. E. Scammon, The Measurement of Man, Minneapolis: University of Minnesota Press, 1930, p. 41-86.

through setting up a relationship between height and weight measurements.[24,25,26,27]

Kretschmer was one of the first to classify body build.[28] He divided all people into three types which he called picnic, athletic, and asthenic. Much controversy was caused; first, only over his choice of words; but later, over his criteria for classifying.

Sheldon,[29] using 4000 subjects, then elaborated on the work of Kretschmer, setting up more objective criteria for classification. He named the three types endomorphs, mesomorphs, and ectomorphs, but allowed for sub-classifications within these categories.

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[24] Ibid., p. 107.

[25] Frank K. Shuttleworth, "The Adolescent Period: A Pictoral Atlas", Monographs of the Society for Research in Child Development, Inc., Vol. XIV, Serial No. 2, 1949, pp.43-53.

[26] W. H. Sheldon, The Varieties of Human Physique, New York: Harper & Bros., 1940.

[27] Norman C. Wetzel, The Treatment of Growth Failure In Children, Cleveland: NEA Service Inc., 1948.

[28] K. Retschmer, E. Korperbau and Charakter. Berlin: Springer, 1921. Translated from the second German edition into English as Physique and Character, by W. J. H. Sprott, London; Kegan Paul, Trench, Trubner, 1925.

[29] Sheldon, op. cit.

This method of classification became quite popular and is still followed by many of the writers today. Some of them are now trying to relate social and mental behavior to these categories. These writers have even characterized certain personality traits as typical of specific body builds.

This study might have as one of its eventual aims the development of a continuous rather than a discrete classification for body build.

Another type of technique for utilizing the relationship between height and weight was the development of the Grid by Wetzel.[30] Children's growth in height and weight, which is charted from month to month, falls into one of seven categories or channels representing build. When an irregular pattern of growth occurs, that is, movement out of a channel, growth failure is suspected. Many times these changes in channels occur even before other symptoms are noticed by the teachers or parents. Seeing, according to Wetzel,[31] irregularities on the grid, enables one to get the child to a physician before disease has gotten sufficiently under way for the typical symptoms to be observed.

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[30] Wetzel, op. cit., p. 11.

[31] Wetzel, op. cit., p.97-98.

Most of the original investigators of body build admit the difficulty in classification by height and weight groupings and find a great many exceptions to the rules which they devised.

Sheldon says:

> Though many physiques showed a strongly predominant trend toward one of the polar extremes, we could find no single individual who did not somewhere in his body also exhibit minor local characteristics belonging to one of the other two polar types.[32]

Wetzel[33] tells how certain children have changed channels or have lagged within their channels when growth failure did not occur.

Shuttleworth[34] gives us a pictoral illustration of a person changing body build.

From this evidence we have good reason to believe that there is no average or typical build, nor is there any natural grouping within which body builds will logically fall. Instead it appears that build, like other aspects of human development, is individual and thus must be described in an individual manner.[35]

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[32] Sheldon, op. cit., p. 47.

[33] Wetzel, op. cit., p. 97.

[34] Shuttleworth, "The Adolescent Period: A Pictoral Atlas", op. cit., pp. 52-53.

[35] A. R. Delong, "An Overview of Child Growth and Development." Phamplet by Child Dev. Lab., Department of Elementary Education, Michigan State College, East Lansing, Michigan.

A technique that represents graphically, individual developments, was developed by W. C. Olson and B. O. Hughes at the University of Michigan.[36] Several measures of specific growths, such as height, weight, cutting of teeth, and standardized test scores are changed into comparable units through the use of conversion tables in a manner similar to the way in which mental test scores are changed into mental ages.[37] A graph is then constructed in which converted scores are placed on the Y or vertical axis and the chronological ages of the child at the times the measurers were taken are placed on the X or horizontal axis. This process makes the scores relatively comparable and relationships among the various aspects of development can be seen.

Another technique, which not only shows these same relationships among individual growth more exactly, but also enables one to predict the course of each growth, has been developed by S. A. Courtis.[38] The Courtis Technique, which

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[36] A. R. DeLong, "A Child Development Concept," Michigan Optometrist, May, 1952.

[37] Willard C. Olson and Byron O. Hughes, "Growth of the Child as a Whole," Child Behavior and Development, ed. by Barker, Kounin, and Wright, New York: McGraw-Hill Book Co., Inc., 1943, Chapter XII.

[38] S. A. Courtis, Maturation Units and How to Use Them, op. cit.

is considerably more involved, assumes a "Law of Growth."[39,40] The raw measures are first converted into precent of development by dividing the specific measures by the maximum at maturity of each growth, within its cycle. These percentages are then converted into growth units, called isochrons, by means of a table. Then a mathematical equation is written that describes not only achieved growth, but also future growth at any point in the cycle if conditions remain somewhat constant.

Since this latest technique promises a solution to the difficulties of other investigators, it was the one chosen to show the relationship of height and weight in this study.

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[39] S. A. Courtis, "Growth and Development in Children," Advance in Health Education, Proceedings of Seventh Health Education Conference, Ann Arbor, Michigan, 1933, New York: American Child Health Association, 1934, pp. 180-206.

[40] S. A. Courtis, "Prediction of Growth," Journal of Educational Research, Vol. XXVI (March 19, 1933), pp. 481-492.

CHAPTER III

PROCEDURE

Data

The data used in this study were taken from the Original Harvard Study. They are summarized in Monographs of the Society For Research In Child Development, entitled "Data On The Growth Of Public School Children" by Walter F. Dearborn, John W. M. Rothney and Frank K. Shuttleworth.[41] The original data on these children can be found in the Child Development Laboratory, Michigan State College, East Lansing, Michigan.

The Harvard Research Study, from which these data were obtained, was begun in 1922.[42] Physical measurements were repeated annually for twelve years.

Anthropometers, calibrated in millimeters, were used for the height measurements.

Weight was measured to the nearest hectogram and was taken with indoor clothing on.

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[41] Walter F. Dearborn, John W. M. Rothney, and Frank K. Shuttleworth, "Data on The Growth of Public School Children," Monographs of the Society for Research in Child Development Vol. III, No. I, Serial No. 14, 1938.

[42] Dearborn and Rothney, Predicting the Child's Development, op. cit. p. 34.

Each of the measurements was taken three times by three different people. Not one of the people measuring saw the results obtained by the others. Therefore, each pupil had nine measurements each time that they were measured. Each measurement of height and weight had to come to within 1.1 units of the other two. When this did not occur, the child was remeasured. The results of the three measurers were averaged according to the following directions:

> 1. Use all measurements that are within 1.1 of others, or when the average of two measures by the same measurer is within 1.1.
>
> 2. In all cases of more than three measurements which are within 1.1 of each other, weight all single measurements by taking them twice and divide by 6.
>
> 3. If there are only 3 measurements which are within 1.1, average them. If not proceed as follows:
>
>   (a) If two can be found with 0.6 average them
>
>   (b) Circle any which vary by more than 2.2 and average all the remaining by weighting.[43]

In order to get as broad a sampling as possible with a limited number of subjects, the cases were selected from the three groupings within which most of the Harvard Girls

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[43] Dearborn and Rothney, Predicting the Child's Development, op. cit. pp. 83-84.

were reported in the Monograph.[44] The individual case numbers are grouped or classified by periods of maximum growth.

Three classifications within which the majority of the girls were placed are: (1) one year of maximum growth ending at age 11.50 to 12.49; (2) one year of maximum growth ending at age 12.50 to 13.49; and (3) one year maximum growth ending at age 13.50 to 14.49.

Seven cases were selected from the 11.50 to 12.49 groups; eleven cases from the 12.50 to 13.49 groups; and seven cases from the 13.50 to 14.49 group, making twenty-five cases in all.

Since further study with these data are anticipated, the following were the requirements that were used in selecting the cases:

1. The subjects were chosen in the order they were listed in their groups. Those that did not meet the subsequent requirements, however, were eliminated.

2. A total of ten or more height and weight measures must be available.

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[44] Dearborn, Rothney, and Shuttleworth, "Data on the Growth of Public School Children," *op. cit.*, pp. 14-15.

3. These ten measurements must not have been labeled in the monograph as probably inaccurate.

4. Other measures for these subjects must be reasonably complete.

Method

Since the organismic concept embodies the individual, longitudinal approach,[45,46] and since a method is available which describes the individual growth curves, mathematically, according to the "Law of Growth",[47,48] this method was selected to show the relationship between height and weight.

Using the Courtis method, the correct portion of the Gompertz curve was fitted to the individual height and weight data. In doing this the following procedure was followed closely:

1. The data were plotted on logarithmic paper.

2. Those points obviously out of the pattern were discarded for purposes of determining the maximum. These points were included when determining the error of the equation.

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[45] Millard, Child Growth and Development in the Elementary School Years, op. cit.

[46] Olson, Child Growth and Development, op.cit., p. 16

[47] Courtis, "Growth and Development in Children," op.cit.

[48] Courtis, "Prediction of Growth," op. cit.

3. Each measurement was divided by the estimated maximum, and the percentage of development was calculated.

4. The results were plotted on isochronic paper. The correct maximum was assumed when the plotted percent of development resulted in a straight line. A positively accelerated curve indicated that the assumed maximum was too low, and a negatively accelerated line indicated that the assumed maximum was too high. An attempt was made to achieve both a positively and a negatively accelerated curve on the isochronic paper before a maximum was accepted as correct. The equation was written from the trial maximum that produced the nearest approximation to a straight line. This maximum was then varied mathematically to more closely approximate the true maximum. The method of least squares was employed to find the maximum when an absurd maximum was needed to produce a negatively accelerated curve or when the curve could not be negatively accelerated.

5. The residuals of the first cycle were used as the data for the second cycle. The same method for determining the maximum was used in writing the second cycle equation.

6. Height and weight cycles were written independently.

The preadolescent and adolescent cycle equations were then written for both height and weight. The means of the three parameters were then determined for each of the three groups for both height and weight. Next, the means of the parameters for all three groups, taken together, were found.

Using these means, a curve of constants[49] was drawn to demonstrate graphically the relationship of height and weight in the preadolescent and adolescent cycle. See Figure 1.

For the purpose of showing a relationship, the percents 20, 50, and 90, were selected. These percentages were arbitrarily chosen in the belief that they would represent an adequate cross section of the total development of a particular cycle.

The individual height and weight equations were then solved to determine the chronological age at 20, 50, and 90 percent of development in both the preadolescent and adolescent cycle. The mean time, or mean chronological age for all girls was then calculated for each of these percents.

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[49] Millard, Child Growth and Development, op. cit.

In order to show the relationship in terms of percent of development, the time at which weight was at 20, 50, and 90 percent of development, for each cycle of each weight equation, was substituted into the corresponding height equation. By this method the percent of height development was found when weight was at 20, 50, and 90 percent of development in the two cycles.

The same procedure was used to determine the percent of weight development when height was at 20, 50, and 90 percent of development in each cycle.

By these methods, the relationships that existed between height and weight could be shown.

The means of the three percentages were next determined, for each of the three groups, first, for height when weight was at the selected percents of development, and then for weight when height was at these percents of development. Then, the means of the individual percents of heights and weights for all three groups, taken together, were found.

CHAPTER IV

ANALYSIS OF THE DATA

The method of collecting the data used in the Harvard Study was undoubtedly one of the most systematic and accurate of any yet published.[50] However, it was discovered that, for the purpose of writing equations using the Courtis technique, more measurements would have resulted in greater accuracy. A minimum of three measurements is necessary when using the Gompertz Function.[51] Some cycles were about four years or less in length. Hence, if there are only three or four measurements, one or more of which may be inaccurate, the measures may not have been a good representation of growth. At least three measures per year would eliminate this inadequacy.

The individual height equations showing the differences in rates, incipiencies, and maxima are found according to groups in Appendices A, B, and C. At the end of each of the Appendicies, each of which contain the data on height for

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[50] Dearborn and Rothney, Predicting the Child's Development, op. cit., pp. 33-99.

[51] Courtis, Maturation Units and How to Use Them, op. cit.

the groups as categorized by Dearborn, Rothney, and Shuttleworth,[52] is found the mean rates, incipiencies, and maxima for that group. Appendix D contains the mean rates, incipiencies, and maxima of all of the girls considered as one group.

For the height growth of the three groups, the rate ranges from 3.17929 to 7.53659 isochrons in the first cycle and from 5.88306 to 11.43709 isochrons in the second cycle. The mean rate for all the girls is 4.68776 in the first and 8.82931 isochrons in the second cycles of height growth.

The height maximum for all groups ranges from 1275 to 1525 millimeters in the first cycle with a mean of 1392. In the second cycle, the range is from 135 to 330 millimeters with a mean of 229.

The range of height incipiencies for the three groups was from -5.81882 to +21.29520 isochrons in the first cycle with a mean of +13.20747 and from -110.94126 to -38.45302 in the second cycle with a mean of -84.68593 isochrons.

The mean maxima, incipiencies, and rates, of the height equations, among the three groups, do not differ noticeably except for the incipiencies in the group which reaches their maximum year of growth at some time ending

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[52]Dearborn, Rothney, and Shuttleworth, op. cit.

between 13.50 and 14.49. With this group, the first cycle incipiency is lower positively than is the first cycle incipiency of the other two groups, and the second cycle incipiency is higher negatively than the second cycle incipiency of the other two groups.

Using the data presented in Appendix D, it was found that having an average of 10.5 measurements for each person and covering an age span of over 9.63 years[53] (including development during two cycles of growth), the average deviation of the description of height growth at all points was ±4.19 millimeters or less than .2 of an inch.

The individual weight equations showing the differences in rates, incipiencies, and maxima are found according to each of the three groups in Appendices E. F, and G. At the end of each of these Appendices is found the mean maxima, rates, and incipiencies for each individual group. Appendix H contains the mean rates, incipiencies, and maxima of all of the girls considered as one group.

The weight rate for the three groups ranges from 3.19344 to 9.64677 isochrons in the first cycle and from 4.50000 to 16.61194 isochrons in the second cycle, with a mean of 5.50069 isochrons in the first cycle and a mean of 7.37374 isochrons in the second cycle.

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[53]From the first measurement in the first cycle to the last measurement in the second cycle.

The weight maximum for all groups ranges from 230 to 450 hectograms with a mean of 306 in the first cycle, and from 104 to 385 hectograms with a mean of 220 in the second cycle.

The range of weight incipiencies of the three groups was from -34.44705 to +18.57897 isochrons in the first cycle with a mean of -.95209 and from -205.33880 to -24.65500 isochrons in the second cycle with a mean of -76.76065.

The mean maxima, incipiencies, and rates, of the weight equations, among the three groups, do not differ noticeably, although the difference among the constants is somewhat greater than was the difference of the constants of the height equations.

The data in Appendix H shows that the weight equations, having an average of 10.4 measures, over an average period of 9.57 years[54] (including development during two cycles of growth) describe growth at all points with an average deviation of 5.50 hectograms or slightly over 18 ounces.

The Curve of constants, Figure 1, shows graphically the relationship of height and weight in the preadolescent and adolescent cycle. In the preadolescent cycle it can be noticed that height growth begins before weight growth and continues ahead until the very end of the cycle, at which time the two curves are quite close together. In the second cycle, the two growths begin at the same time, but the

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[54] From the first measurement in the first cycle to the last measurement in the second cycle.

height rate is greater than the weight rate so that height is again ahead of weight and remains so until the end of the cycle.

The individual chronological ages when height was at 20, 50, and 90 percent of development, in the preadolescent and adolescent cycle, is presented according to groups in Appendicies I, J, and K. Appendix L, shows the mean chronological ages of all the subjects, taken together. Twenty, 50, and 90 percent of growth in height in the first cycle, occur at a mean age of 2.40, 4.28, and 8.42 years respectively. In the second cycle, 20 percent of height growth occurs at a mean age of 11.39 years, 50 percent at a mean age of 12.42 years, and 90 percent at a mean of 14.63 years.

The individual chronological ages when weight was at 20, 50, and 90 percent of development, in the preadolescent and adolescent cycle, is presented according to groups in Appendicies M, N, and O. Appendix P shows the mean chronological age when weight is at the above percents of development. In the first cycle 20 percent of weight growth occurs at a mean chronological age of 4.49 years, 50 percent of weight growth occurs at a mean age of 6.21 years, and 90 percent of weight growth occurs at a mean age of 9.97 years. In the second cycle 20, 50, and 90 percent of growth in weight occur at 11.83, 13.09, and 15.86 years respectively.

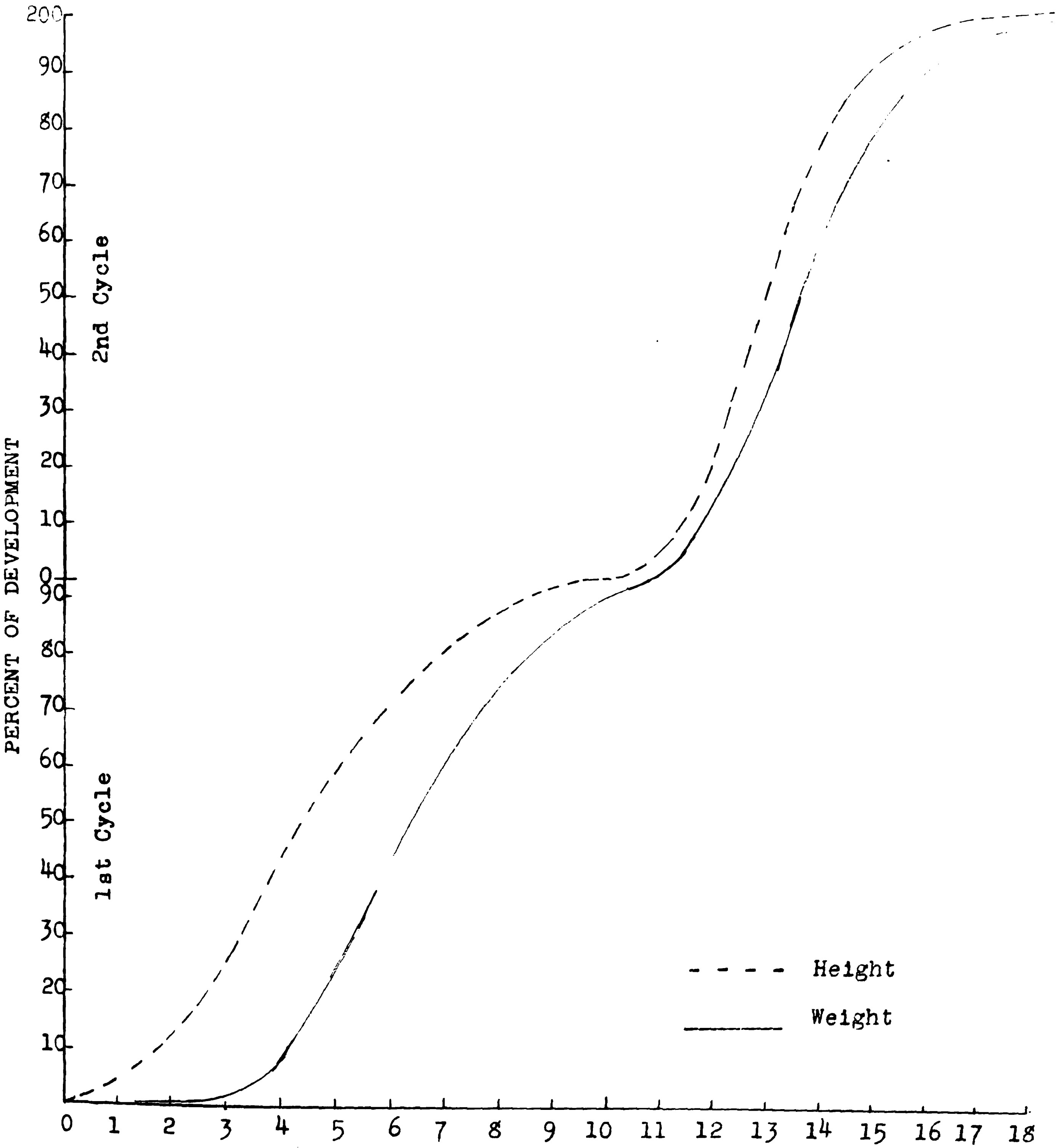


Figure 1.

CURVES OF CONSTANTS

The 2nd cycle is begun at 92.6 % of the first cycle to show continuous growth.

Table I shows the individual percent of development of height when weight is at 20, 50, and 90 percent of development in the preadolescent and adolescent cycle, for seven girls who achieve one year of maximum growth ending at 11.50 to 12.49. The mean percent of height development for this group when weight is at 20, 50, and 90, percent of development in the two cycles is 52.2, 74.9, and 94.9 for the first cycle and 26.5, 58.6, and 92.1 for the second cycle.

Table II shows the individual percent of development of height when weight is at 20, 50, and 90 percent of development in the preadolescent and adolescent cycle for eleven girls who achieve one year of maximum growth ending at 12.50 to 13.49. The mean percent of height development for this group when weight is at 20, 50, and 90, percent of development in the two cycles is 50.5, 72.1, and 93.3 for the first cycle and 33.0, 73.6, and 95.4, for the second cycle.

Table III shows the individual percent of development of height when weight is at 20, 50, and 90 percent of development in the preadolescent and adolescent cycle for seven girls who achieve one year of maximum growth ending at 13.50 to 14.49. The mean percent of height development for this group when weight is at 20,50, and 90 percent of development in the two cycles is 52.9, 75.1, and 95.0 for the first cycle and 31.9, 69.6,and 95.7 for the second cycle.

Table IV shows the mean percent of development of height for all cases when weight is at 20, 50, and 90 percent of development in the preadolescent and adolescent cycle. The mean percent of height development for all cases when weight is at 20, 50, and 90 percent of development in the two cycles is 51.6, 73.8, and 94.2 for the first cycle and 30.9, 67.6 and 94.6 for the second cycle. From the illustrated standard error of the mean, confidence limits can be set up to show that at 20 percent of weight development in the first cycle, the mean height development of the population (all girls of this age), is between 41.07 and 62.13 almost 100 percent of the time. At 50 percent of weight development in the first cycle, the mean height development of the population will be between 68.61 and 78.99 almost 100 percent of the time. The mean height development of the population at 90 percent of development in the first cycle will be between 91.83 and 96.57 almost 100 percent of the time. For the second cycle, the mean height development of the population at 20, 50, and 90 percent of weight development will be between 23.31 and 38.49, between 61.54 and 73.66, and between 91.36 and 97.84 respectively almost 100 percent of the time.

TABLE I

PERCENT OF DEVELOPMENT OF HEIGHT WHEN WEIGHT IS AT 20, 50, AND 90 PERCENT OF DEVELOPMENT

Girls One Year Maximum Growth Ending at 11.50-12.49

Case		Percent of Weight Development 1st Cycle			Percent of Weight Development 2nd Cycle		
		20	50	90	20	50	90
62F	% Ht.Dev.	53.9	80.0	97.7	21.4	66.4	97.9
98F	% Ht.Dev.	67.7	77.5	90.8	28.3	59.9	93.4
411F	% Ht.Dev.	56.1	78.9	96.8	30.6	68.0	96.9
424F	% Ht.Dev.	47.0	68.6	92.4	8.6	28.8	77.2
503F	% Ht.Dev.	44.4	71.9	95.7	36.3	59.5	88.9
693F	% Ht.Dev.	59.3	76.6	94.2	24.5	60.1	94.9
889F	% Ht.Dev.	37.3	71.0	96.8	35.7	67.6	95.6
	Mean	52.2	74.9	94.9	26.5	58.6	92.1

TABLE II

PERCENT OF DEVELOPMENT OF HEIGHT WHEN
WEIGHT IS AT 20, 50, AND 90 PERCENT OF DEVELOPMENT

Girls One Year Maximum Growth Ending at 12.50-13.49

Case		Percent of Weight Development 1st Cycle			Percent of Weight Development 2nd Cycle		
		20	50	90	20	50	90
6F	% Ht.Dev.	44.7	65.7	82.7	27.6	69.5	97.9
29F	% Ht.Dev.	55.7	70.9	90.1	21.7	73.1	99.0
52F	% Ht.Dev.	72.4	79.9	90.6	23.9	77.1	99.4
61F	% Ht.Dev.	66.8	75.7	88.6	19.2	76.5	99.5
95F	% Ht.Dev.	35.7	73.1	97.8	33.7	61.7	92.4
105F	% Ht.Dev.	20.1	43.4	94.2	43.1	71.2	90.4
111F	% Ht.Dev.	34.4	71.5	97.5	7.0	62.5	99.0
129F	% Ht.Dev.	32.4	71.3	97.7	51.7	78.1	97.3
152F	% Ht.Dev.	79.1	89.9	98.2	54.7	78.9	97.1
158F	% Ht.Dev.	77.7	85.1	93.6	49.1	65.3	87.4
191F	% Ht.Dev.	37.0	67.1	94.9	31.6	77.1	90.1
	Mean	50.5	72.1	93.3	33.0	73.6	95.4

TABLE III

PERCENT OF DEVELOPMENT OF HEIGHT WHEN
WEIGHT IS AT 20, 50, AND 90 PERCENT OF DEVELOPMENT

Girls One Year Maximum Growth Ending at 13.50-14.49

Case		Percent of Weight Development 1st Cycle			Percent of Weight Development 2nd Cycle		
		20	50	90	20	50	90
54F	% Ht.Dev.	63.0	82.1	97.1	26.0	66.6	97.3
275F	% Ht.Dev.	72.1	82.6	94.4	38.6	71.0	96.6
320F	% Ht.Dev.	38.7	68.2	95.1	28.4	64.3	95.8
329F	% Ht.Dev.	13.2	57.6	97.0	22.1	77.7	98.5
612F	% Ht.Dev.	53.3	78.6	97.3	31.6	72.5	98.1
776F	% Ht.Dev.	66.7	74.9	86.6	19.9	67.2	98.4
1050F	% Ht.Dev.	61.1	81.8	97.4	56.5	68.2	85.5
	Mean	52.9	75.1	95.0	31.9	69.6	95.7

TABLE IV

MEAN PERCENT OF DEVELOPMENT OF HEIGHT WHEN WEIGHT IS AT 20, 50, AND 90 PERCENT OF DEVELOPMENT

	Percent of Weight Development 1st Cycle			Percent of Weight Development 2nd Cycle		
	20	50	90	20	50	90
All Cases % Ht. Dev.	51.6	73.8	94.2	30.9	67.6	94.6
Stan. Dev.	17.2	8.5	3.9	12.4	9.9	5.3
Stan. Error of Mean	3.51	1.73	.79	2.53	2.02	1.08

Tables V, VI, and VII show the individual percent of development of weight, for each of the three groups, when height is at 20, 50, and 90 percent of development in the preadolescent and adolescent cycle.

Table VIII presents the mean percent of development of weight for all cases when height is at 20, 50, and 90 percent of development in the two cycles.

These tables were done as a check on the other work, to show more clearly the relationship of height to weight and to weight and to discover if any other relationships could be shown by this process.

TABLE V

PERCENT OF DEVELOPMENT OF WEIGHT WHEN
HEIGHT IS AT 20, 50, AND 90 PERCENT OF DEVELOPMENT

Girls One Year Maximum Growth Ending at 11.50-12.49

Case		Percent of Height Development 1st Cycle			Percent of Weight Development 2nd Cycle		
		20	50	90	20	50	90
62F	% Wt.Dev.	2.9	17.0	68.8	4.4	38.1	74.8
98F	% Wt.Dev.	___*	.8	88.1	13.3	40.0	85.4
411F	% Wt.Dev.	1.4	14.9	72.6	13.1	34.0	76.8
424F	% Wt.Dev.	1.8	23.3	86.2	38.8	70.8	96.5
503F	% Wt.Dev.	4.8	25.1	78.8	5.4	36.9	91.2
693F	% Wt.Dev.	.1	10.0	80.6	16.5	40.7	84.1
889F	% Wt.Dev.	9.3	29.7	76.2	9.2	31.8	80.3
	Mean	2.5	17.3	78.8	17.8	38.3	84.2

*A dash indicates that a minus number of isochrons was gotten and therefore, weight was at a point before the beginning of the preadolescent cycle.

TABLE VI

PERCENT OF DEVELOPMENT OF WEIGHT WHEN
HEIGHT IS AT 20, 50, AND 90 PERCENT OF DEVELOPMENT

Girls One Year Maximum Growth Ending at 12.50-13.49

Case		Percent of Height Development 1st Cycle			Percent of Weight Development 2nd Cycle		
		20	50	90	20	50	90
6F	% Wt.Dev.	1.9	26.6	90.1	15.4	34.5	73.9
29F	% Wt.Dev.	0.0	15.0	89.9	19.1	34.7	68.0
52F	% Wt.Dev.	___	0.0	88.4	18.2	32.4	64.2
61F	% Wt.Dev.	___	.4	92.5	20.4	34.2	64.1
95F	% Wt.Dev.	11.0	29.7	72.7	8.8	36.5	86.7
105F	% Wt.Dev.	33.1	54.5	85.4	2.5	28.5	89.4
111F	% Wt.Dev.	11.4	30.8	74.3	28.5	43.3	71.6
129F	% Wt.Dev.	12.7	31.9	61.2	3.2	18.8	71.6
152F	% Wt.Dev.	.0	.6	50.4	2.0	15.9	71.7
158F	% Wt.Dev.	___	0.	75.2	.1	21.3	93.2
191F	% Wt.Dev.	8.1	31.6	81.7	14.3	30.0	65.9
	Mean	9.8	20.1	78.3	12.05	30.0	71.9

TABLE VII

PERCENT OF DEVELOPMENT OF WEIGHT WHEN
HEIGHT IS AT 20, 50, AND 90 PERCENT OF DEVELOPMENT

Girls One Year Maximum Growth Ending at 13.50-14.49

Case		Percent of Height Development 1st Cycle			Percent of Weight Development 2nd Cycle		
		20	50	90	20	50	90
54F	% Wt.Dev.	.4	9.0	69.0	16.1	36.4	76.4
275F	% Wt.Dev.	0	.5	73.1	8.4	29.1	77.0
320F	% Wt.Dev.	7.2	30.1	81.1	14.1	37.1	80.7
329F	% Wt.Dev.	25.0	44.8	78.9	18.6	38.6	76.5
612F	% Wt.Dev.	2.7	17.4	71.4	13.4	31.8	72.2
776F	% Wt.Dev.	—	.1	95.5	20.1	37.6	72.5
1050F	% Wt.Dev.	.8	11.0	68.4	0	8.7	95.7
	Mean	6.0	16.1	76.8	13.0	31.3	78.7

TABLE VIII

MEAN PERCENT OF DEVELOPMENT OF WEIGHT WHEN HEIGHT IS AT 20, 50, AND 90 PERCENT OF DEVELOPMENT

	Percent of Height Development 1st Cycle			Percent of Height Development 2nd Cycle		
	20	50	90	20	50	90
All Cases % Ht. Dev.	6.5	18.2	78.0	13.0	33.7	78.4
Stan. Dev.	8.6	14.9	10.2	9.0	11.1	9.4
Stan. Error	1.95	3.04	2.08	1.84	2.27	1.92

CHAPTER V

SUMMARY, CONCLUSIONS, AND IMPLICATIONS

This study was carried out to determine the relationships existing between height and weight growth of girls in the preadolescent and adolescent cycles.

Twenty-five girls were selected from the Harvard Data.

In the sampling criteria employed, the cases selected were those that contained a minimum of ten measures each, of height and weight, as well as reasonably complete supplementary data so that further research might be carried out with these cases.

Equations representing achieved growth in both height and weight within the preadolescent and adolescent cycle were written utilizing the Courtis adaptation of the Gompertz Function.

The height and weight equations were solved for 20, 50, and 90 percent of development in both cycles. Thus the chronological age at which each equation was at 20, 50, and 90 percent of development was found.

These times were then substituted in the opposite equation to determine the relationship. The times when achieved growth in weight was at 20, 50, and 90 percent of development were substituted in the height equation to determine where height was in terms of percent. The times when achieved growth in height was at 20, 50, and 90 percent of development were substituted in the weight equations to determine where weight was in terms of percent of development. This was done as a check to assure the accuracy of the results.

Conclusions

In all groups height achieved a higher percent of development than did weight at any given time.

The individual curves were then examined for each of the three percentages of development. It was found that in some individual cases (9), there were one or at the most two points at which weight development was higher than that of height. These points usually occurred at the end of the cycle. The cause is not known, but this might have been due to the influence of the succeeding cycle.

At 20 percent of weight development in the first cycle, height was at a percentage greater than 20 percent, 96 percent of the time.

At 50 percent of weight development in the first cycle, height was at a percentage greater than 50 percent, 96 percent of the time.

At 90 percent of weight development in the first cycle, height was at a percentage greater than 90 percent, 88 percent of the time.

In the second cycle when weight was at 20 percent of development, height was at a percentage greater than 20 percent, 84 percent of the time.

In the second cycle, when weight was at 50 percent of development, height was at a percentage greater than 50 percent, 96 percent of the time.

In the second cycle, when weight is at 90 percent of development, height is at a percentage greater than 90 percent, 84 percent of the time.

In no case was weight ahead of height for two cycles.

In one case, subject 424F, weight was ahead of height for a complete cycle, the second cycle.

This study has shown that a definite relationship exists between the developmental patterns of height and weight of girls in the adolescent and preadolescent cycle, as described by the Gompertz Curve.

Implications

The writer would like to see the same procedure used with more frequent measures. Boys might also be included in a future study.

Individual cases should be analyzed more closely to determine the degree of individual variation from the general trend as well as to determine individual patterns of the relationship between height and weight.

Ideally, subjective data, such as a case inventory, should be included so as to determine causes of changes in conditions such as prolonged illness, or change in diet, being responsible for variation.

APPENDIX

APPENDIX A

GROUP WITH ONE YEAR MAXIMUM GROWTH ENDING AT AGE 11.50-12.49+
GROWTH CONSTANTS: HEIGHT EQUATIONS
(y - K (rt - 1) A^D)

Case	Cycle	K Maximum in Millimeters	Rate r	Incipiency i	A.D. Ave. Dev. by cycle	Ave.Dev. both cycles	Age span both cycles*	No. of Measures Both Cycles
62F	1	1400	5.76471	+6.20703	±5.33	±3.00	9.03	10
	2	194	10.05473	-84.84506	±1.75			
98F	1	1480	3.82653	+20.80103	±1.67	±2.67	10.97	12
	2	252	8.18729	-61.89477	±3.00			
411F	1	1390	4.59512	+16.36440	±2.67	±3.73	10.01	11
	2	233	9.93548	-83.45705	±4.2			
424F	1	1375	3.81362	+21.49520	±3.25	±5.17	10.95	12
	2	229	7.12667	-53.99597	±5.44			
503F	1	1360	4.55721	+14.66092	± .67	±2.92	11.10	12
	2	199	10.60765	-88.61855	±3.50			
693F	1	1285	5.77612	+ 8.77403	± .50	±6.40	10.04	10
	2	249	7.99003	-58.48923	±7.00			
889F	1	1325	4.20398	+18.41562	±1.33	±3.00	11.10	12
	2	215	9.12040	-73.90126	±3.56			
Means	1	1374	4.64818	+15.24549	±2.20	±3.84	10.46	11.3
	2	224	9.00318	-72.17169	±4.05			

* From the first measurement in the first cycle to the last measurement in the second cycle.

+ Groups adapted from data on the growth of Public School Children, by Dearborn, Rothney and Shuttleworth.

APPENDIX B

GROUP WITH ONE YEAR MAXIMUM GROWTH ENDING AT AGE 12.50-13.49 + GROWTH CONSTANTS: HEIGHT EQUATIONS
$(y - K (rt - i) A^D)$

Case	Cycle	k Maximum in Millimeters	Rate r	Incipiency i	A.D. Ave.Dev. by cycle	Ave.Dev. both cycles	Age Span both cycles*	No. of Measures Both Cycles
6F	1	1500	3.19697	+19.32257	±2.25	±2.40	9.02	10
	2	147	10.70895	-106.39262	±2.83			
29F	1	1525	3.17929	+ 20.83393	±4.25	±3.67	11.01	12
	2	135	9.58974	- 90.36560	±2.88			
52F	1	1425	3.87562	+ 19.11375	± .33	±3.55	9.99	11
	2	272	9.74600	- 90.82276	±4.75			
61F	1	1454	3.84653	+ 19.49177	±3.00	±4.82	9.99	11
	2	230	11.43709	-104.82985	±5.50			
95F	1	1375	5.45455t	+ 12.47542	±4.67	±5.73	9.98	11
	2	280	7.05000	- 51.83200	±5.56			
105F	1	1320	5.74257	+ 10.73597	±4.33	±3.18	10.01	11
	2	330	5.88306	- 38.45302	±2.44			
111F	1	1525	4.37313	+ 15.95720	± .67	± .89	9.01	9
	2	158	10.57000	- 96.27160	±1.00			
129F	1	1310	7.53659	- 4.81882	± .00	±3.91	11.25	11
	2	280	7.74247	- 60.45482	±4.78			

APPENDIX B -- Continued

Case	Cycle	k Maximum in Millimeters	Rate r	Incipiency i	A.D. Ave.Dev. by cycle	Ave.Dev. both cycles	Age Span both cycles*	No. of Measures both cycles
152F	1	1320	4.70854	+16.27560	±3.33	±6.45	10.01	11
	2	270	7.91750	-63.35350	±7.62			
158F	1	1275	4.57282	+15.92715	±1.67	±6.33	8.18	9
	2	300	5.88729	-40.11876	±8.67			
191F	1	1500	3.76500	+21.48860	± .33	±4.82	10.00	11
	2	235	7.96992	-59.80604	±6.50			
Means	1	1412	4.56833	+15.16210	±2.26	±4.16	9.86	10.6
	2	240	8.59109	-72.97320	±4.78			

* From the first measurement in the first cycle to the last measurement in the second cycle.

† Groups adapted from data on the growth of Public School Children, by Dearborn Rothney and Shuttleworth.

APPENDIX C

GROUP WITH ONE YEAR MAXIMUM GROWTH ENDING AT AGE 13.50-14.49
GROWTH CONSTANTS: HEIGHT EQUATIONS
$(y - K\ (rt - i)\ A^D)$

Case	Cycle	k Maximum in Millimeters	Rate r	Incipiency i	A.D. Ave.Dev. by cycle	Ave.Dev. both cycles	Age Span both cycles*	No. of Measures both cycles
54F	1	1350	4.51980	+ 12.68516	±4.33	±6.18	10.01	11
	2	272	8.27273	- 70.92003	±6.88			
275F	1	1380	5.84390	+ 3.25685	±4.00	±4.89	8.06	9
	2	185	10.03679	- 93.46171	±5.33			
320F	1	1320	5.38806	+ 9.33358	±4.33	±6.00	9.01	10
	2	243	8.11250	- 68.10400	±6.71			
329F	1	1425	5.07426	+ 5.14909	±3.33	±4.00	8,02	9
	2	235	10.57711	-105.92049	±4.33			
612F	1	1355	4.98010	+ 6.88228	±1.00	±2.67	8.00	9
	2	219	7.48333	- 70.81062	±3.50			
776F	1	1420	3.30500	+ 18.22615	±5.25	±3.67	8.01	9
	2	155	10.92691	-110.94126	±1.83			
1050F	1	1400	5.54412	+ 1.14380)	±3.00	±4.67	7.99	9
	2	220	7.79934	- 72.64346)	±5.50			
Mean	1	1379	4.95075	+ 8.09670	±3.61	±4.58	8.44	9.4
	2	218	9.02982	- 84.68593	±4.87			

*From the first measurement in the first cycle to the last measurement in the second cycle.

APPENDIX D

MEAN GROWTH CONSTANTS ALL GROUPS HEIGHT EQUATIONS

Cycle	Maximum	Rate	Incipiency	Ave.Dev. by Cycle	Ave.Dev. both Cycles	Age Span both Cycles	No. of Measures both Cycles
1	1392	4.69776	+13.20747	±2.62	±4.19	9.63	10.5
2	229	8.82931	-76.02816	±4.60			

APPENDIX E

GROUP WITH ONE YEAR MAXIMUM GROWTH ENDING AT AGE 11.50-12.49 +
GROWTH CONSTANTS: WEIGHT EQUATIONS
$(y \,^{-}K\ (rt - i)\ A^D)$

Case	Cycle	k Maximum in Hectograms	Rate r	Incipiency i	A.D. Ave.Dev. by Cycle	Ave.Dev. both Cycles	Age Span both Cycles*	No. of Measures both Cycles
62F	1 2	330 120	4.76000 6.41709	+ 1.61560 -45.29247	± .33 ±3.89	±4.00	8.02	9
98F	1 2	320 338	7.38265 7.65886	+10.50386 -58.51519	±3.33 ±6.44	±5.67	10.97	12
411F	1 2	355 180	4.35323 7.44147	+ 7.13650 -58.48737	± .33 ±6.00	±5.44	9.01	10
424F	1 2	257 180	4.62360 8.57333	+11.50413 -64.79103	± .67 ±9.56	±7.33	10.95	12
503F	1 2	316 165	4.25373 13.48000	+ 9.01702 -125.38000	±1.75 ±10.22	±7.00	12.06	13
693F	1 2	255 200	7.26599 6.62155	+ 9.64850 -45.27785	± .67 ±5.33	±4.55	11.00	11
889F	1 2	280 260	3.34328 7.98328	+15.92241 -65.47374	±1.00 ±18.67	±14.33	11.10	12
Mean	1 2	302 206	5.14035 8.31084	+ 3.57761 -66.17395	±1.15 ±7.39	±6.90	10.44	11.3

*From the first measurement in the first cycle to the last measurement in the second cycle.

+Groups adapted from data on the growth of Public School Children, by Dearborn, Rothney, and Shuttleworth

APPENDIX F

GROUP WITH ONE YEAR MAXIMUM GROWTH ENDING AT AGE 12.50-13.49 +
GROWTH CONSTANTS: WEIGHT EQUATIONS
$(y = K(rt - i) A^D)$

Case	Cycle	k Maximum in Hectograms	Rate r	Incipiency i	A.D. Ave.Dev. by Cycle	Ave.Dev. both Cycles	Age Span both Cycles*	No. of Measures both Cycles
6F	1	300	4.15610	+ 8.52500	± 1.80	±2.30	9.02	10
	2	219	7.14358	-64.05825	± 3.58			
29F	1	299	5.03311	+ 2.24876	± 2.25	±2.91	10.07	11
	2	235	5.13095	-36.91187	± 3.29			
52F	1	270	8.87562	-25.51625	± .00	±4.27	9.99	11
	2	285	4.80798	-32.60222	± 5.88			
61F	1	280	8.67327	-18.91665	± .33	±2.55	9.99	11
	2	280	5.29801	-34.87301	± 3.00			
95F	1	320	3.87291	+13.00589	± .25	±5.00	9.98	11
	2	200	7.33168	-59.01679	± 6.75			
105F	1	230	4.11386	+18.57892	± 1.67	±9.09	10.01	11
	2	245	7.56711	-65.05572	±11.88			
111F	1	450	3.19344	+15.43631	± 1.67	±7.90	10.02	10
	2	225	5.14787	-31.47670	±10.57			
129F	1	275	5.27317	+ 1.72844	± .00	±7.55	11.25	11
	2	230	6.62406	-55.69812	± 9.22			
152F	1	350	5.01980	- 4.82176	± .33	±6.33	8.02	9
	2	205	7.18333	-64.07996	± 8.00			

APPENDIX F -- Continued

Case	Cycle	k Maximum in Hectograms	Rate r	Incipiency i	A.D. Ave.Dev. by Cycle	Ave.Dev. both Cycles	Age Span both Cycles*	No. of Measures both Cycles
158F	1	240	9.64677	-34.44705	± .33	±5.25	7.17	8
	2	219	9.64384	-95.19937	±8.20			
191F	1	380	3.48500	+17.28140	± .33	±3.18	10.00	11
	2	385	4.50000	-24.65500	±5.67			
Mean	1	309	5.57662	- .62699	± .82	±5.12	9.59	10.4
	2	248	6.39804	-51.23881	±6.91			

* From the first measurement in the first cycle to the last measurement in the second cycle.

+ Groups adapted from data on the growth of Public School Children, by Dearborn, and Shuttleworth.

APPENDIX G

GROUP WITH ONE YEAR MAXIMUM GROWTH ENDING AT AGE 13.50-14.49 +
GROWTH CONSTANTS: WEIGHT EQUATIONS
$(y - K\ (rt - i)\ A^{D})$

Case	Cycle	K Maximum in Hectograms	Rate r	Incipiency i	A.D. Ave. Dev. by Cycle	Ave. Dev. both Cycles	Age Span both Cycles*	No. of Measures both Cycles
54F	1	350	4.48020	+ .41484	± 1.33	±10.73	10.01	11
	2	202	5.80272	- 43.44631	±14.25			
275F	1	310	9.15563	- 34.20286	± 3.50	± 5.33	8.50	9
	2	195	8.28763	- 77.09976	± 5.67			
320F	1	254	5.00000	+ 5.57000	± 1.33	± 3.40	9.01	10
	2	220	6.54271	- 52.01700	± 4.57			
329F	1	300	3.29000	+ 13.69030	± 1.75	± 1.64	9.99	11
	2	160	7.11667	- 63.44071	± 1.57			
612F	1	350	4.35323	+ 1.00441	± .67	± 5.00	8.00	9
	2	270	4.99250	- 41.06130	± 7.17			
776F	1	262	8.72500	- 29.71325	± .00	± 3.89	8.01	9
	2	170	6.43522	- 54.92072	± 5.83			
1050F	1	320	5.18812	- 8.35556	± 1.33	± 2.88	7.00	8
	2	104	16.61194	-205.33880	± 4.00			
Mean	1	307	5.74174	- 7.37030	± 1.42	± 4.70	8.65	9.6
	2	189	7.96991	- 76.76065	± 6.15			

* From the first measurement in the first cycle to the last measurement in the second cycle.

+ Groups adapted from data on the growth of Public School Children, by Dearborn, and Shuttleworth.

APPENDIX H

MEAN GROWTH CONSTANTS ALL GROUPS WEIGHT EQUATIONS

Cycle	Maximum	Rate	Incipiency	Ave.Dev. by Cycle	Ave.Dev. both Cycles	Age Span both Cycles	No. of Measures both Cycles
1	306	5.50069	- .95209	±1.08	±5.50	9.57	10.4
2	220	7.37374	-62.56702	±7.17			

APPENDIX I

CHRONOLOGICAL AGE WHEN HEIGHT IS AT 20, 50, AND 90 PERCENT OF DEVELOPMENT

Girls One Year Maximum Growth Ending at Age 11.50-12.49

		1st Cycle			2nd Cycle		
Percent of Dev.		20	50	90	20	50	90
62F	C.A.	3.30	4.76	8.03	9.96	11.79	13.66
98F	C.A.	1.16	3.36	8.28	10.64	11.67	13.97
411F	C.A.	1.93	3.77	7.87	10.94	11.79	13.68
424F	C.A.	.98	3.19	8.13	11.12	12.30	14.94
503F	C.A.	2.32	4.17	8.30	10.73	11.53	13.20
693F	C.A.	2.85	4.31	7.57	10.48	11.53	14.02
889F	C.A.	1.62	3.63	8.11	10.87	11.79	13.86

APPENDIX J

CHRONOLOGICAL AGE WHEN HEIGHT IS AT 20, 50, AND 90 PERCENT OF DEVELOPMENT

Girls One Year Maximum Growth Ending at Age 12.50-13.49

	1st Cycle			2nd Cycle		
Percent of Dev.	20	50	90	20	50	90
6F C.A.	1.85	4.49	10.37	12.29	13.08	14.84
29F C.A.	1.39	4.04	9.96	12.06	12.93	14.90
52F C.A.	1.58	3.76	8.61	11.91	12.77	14.71
61F C.A.	1.49	3.69	8.58	11.37	12.11	13.76
95F C.A.	2.34	3.89	7.34	10.93	12.13	14.80
105F C.A.	2.53	3.99	7.27	10.83	12.26	15.46
111F C.A.	2.13	4.05	8.36	11.50	12.29	14.07
129F C.A.	3.99	5.11	6.71	11.07	12.16	14.59
152F C.A.	1.90	3.69	7.69	11.19	12.25	14.63
158F C.A.	2.04	3.88	7.98	11.10	12.53	15.73
191F C.A.	1.00	3.24	8.24	10.67	11.73	14.09

APPENDIX K

CHRONOLOGICAL AGE WHEN HEIGHT IS AT
20, 50, AND 90 PERCENT OF DEVELOPMENT

Girls One Year Maximum Growth Ending at Age 13.50-14.49

	1st Cycle			2nd Cycle		
Percent of Dev.	20	50	90	20	50	90
54F C.A.	2.78	4.64	8.81	11.62	12.64	14.92
275F C.A.	3.76	5.20	8.28	11.83	12.67	14.54
320F C.A.	2.95	4.52	8.01	11.51	12.55	14.89
329F C.A.	3.96	5.62	9.33	12.40	13.20	14.98
612F C.A.	3.69	5.38	9.16	12.84	13.96	16.48
776F C.A.	2.12	4.67	10.37	12.46	13.23	14.96
1050F C.A.	4.35	5.87	9.26	12.55	13.63	16.05

APPENDIX L

MEAN CHRONOLOGICAL AGE WHEN HEIGHT IS
AT 20, 50, AND 90 PERCENT OF DEVELOPMENT

7 Girls One Year Maximum Growth Ending at Age 11.50-12.49
11 Girls One Year Maximum Growth Ending at Age 12.50-13.49
7 Girls One Year Maximum Growth Ending at Age 13.50-14.49

	1st Cycle			2nd Cycle		
Percent of Dev.	20	50	90	20	50	90
Mean all Girls C.A.	2.40	4.28	8.42	11.39	12.42	14.63

APPENDIX M

CHRONOLOGICAL AGE WHEN WEIGHT IS AT
20, 50, AND 90 PERCENT OF DEVELOPMENT

Girls One Year Maximum Growth Ending at Age 11.50-12.49

	1st Cycle			2nd Cycle		
Percent of Dev.	20	50	90	20	50	90
62F C.A.	4.96	6.73	10.69	10.99	12.31	15.24
98F C.A.	4.84	5.98	8.53	10.94	12.04	14.50
411F C.A.	4.16	6.10	10.42	11.25	12.38	14.91
424F C.A.	2.97	4.79	8.87	10.53	11.53	13.68
503F C.A.	3.82	5.80	10.22	11.17	11.80	13.20
693F C.A.	4.80	5.96	8.55	10.65	11.92	14.77
889F C.A.	2.79	5.31	10.94	11.36	12.42	14.78

APPENDIX N

CHRONOLOGICAL AGE WHEN WEIGHT IS AT
20, 50, AND 90 PERCENT OF DEVELOPMENT

Girls One Year Maximum Growth Ending at Age 12.50-13.49

	1st Cycle			2nd Cycle		
Percent of Dev.	20	50	90	20	50	90
6F C.A.	4.02	6.05	8.53	12.50	13.68	16.32
29F C.A.	4.57	6.24	9.98	12.11	13.76	17.43
52F C.A.	5.72	6.67	8.79	12.03	13.78	17.70
61F C.A.	5.09	6.06	8.23	11.35	12.94	16.49
95F C.A.	3.16	5.34	10.20	11.49	12.64	15.21
105F C.A.	1.62	3.67	8.25	11.93	13.47	15.54
111F C.A.	3.07	5.71	11.61	11.02	12.66	16.31
129F C.A.	4.46	6.06	9.63	12.22	13.49	16.33
152F C.A.	5.99	7.67	11.42	12.43	13.61	16.23
158F C.A.	6.19	7.06	9.01	12.49	13.36	15.32
191F C.A.	2.28	4.70	10.11	11.09	12.96	17.15

APPENDIX O

CHRONOLOGICAL AGE WHEN WEIGHT IS AT
20, 50, AND 90 PERCENT OF DEVELOPMENT

Girls One Year Maximum Growth Ending at Age 13.50-14.49

	1st Cycle			2nd Cycle		
Percent of Dev.	20	50	90	20	50	90
54F C.A.	5.54	7.42	11.63	11.84	13.29	16.53
275F C.A.	6.49	7.41	9.47	12.35	13.37	15.64
320F C.A.	3.93	5.62	9.39	11.81	13.10	15.97
329F C.A.	3.51	6.07	11.80	12.46	13.65	16.29
612F C.A.	5.57	7.50	11.83	13.28	14.97	18.74
776F C.A.	6.30	7.26	9.42	12.46	13.77	16.69
1050F C.A.	6.48	8.10	11.73	13.88	14.39	15.52

APPENDIX P

MEAN CHRONOLOGICAL AGE WHEN WEIGHT IS AT 20, 50, AND 90 PERCENT OF DEVELOPMENT

7 Girls One Year Maximum Growth Ending at Age 11.50-12.49
11 Girls One Year Maximum Growth Ending at Age 12.50-13.49
7 Girls One Year Maximum Growth Ending at Age 13.50-14.49

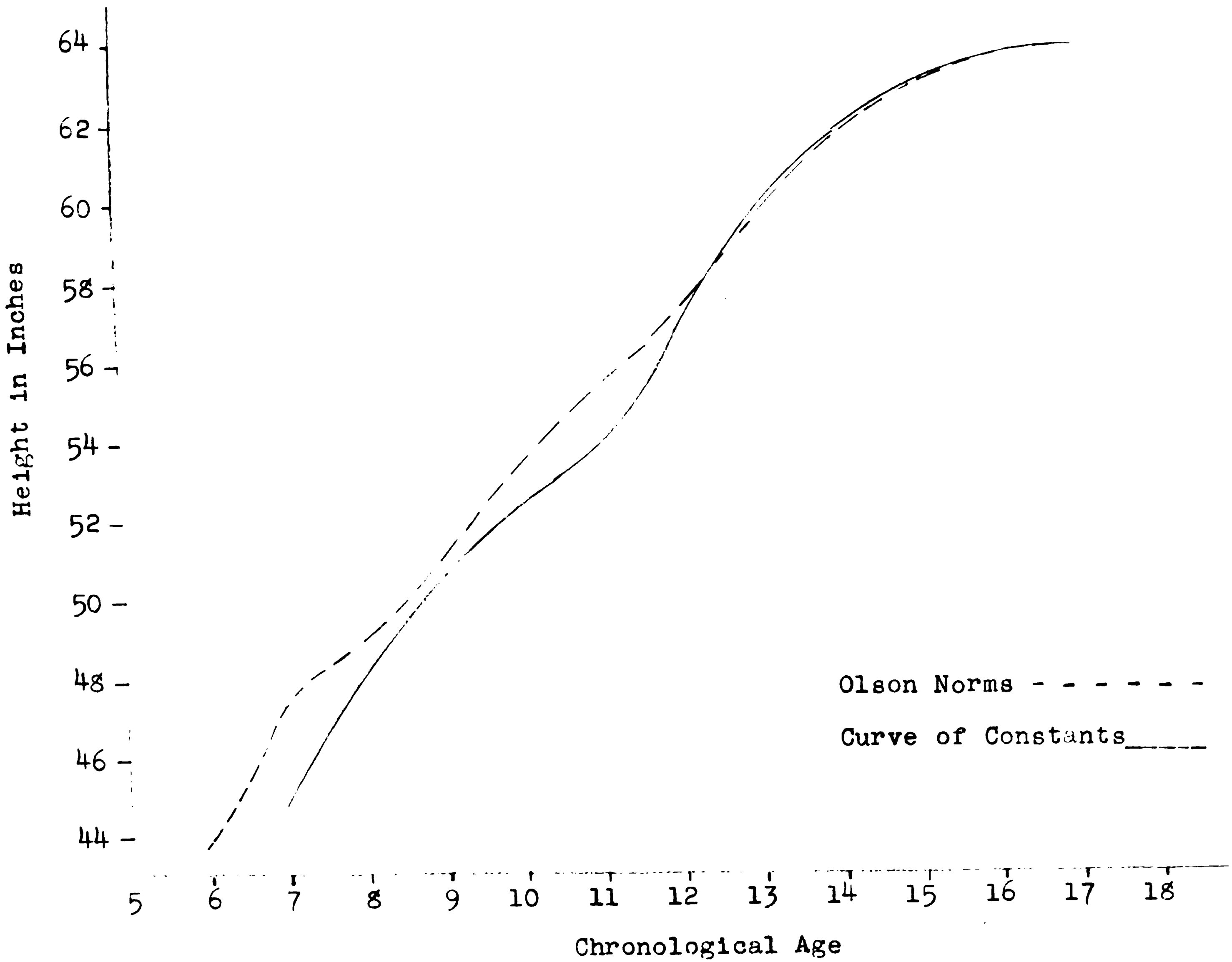
	1st Cycle			2nd Cycle		
Percent of Dev.	20	50	90	20	50	90
Mean all Girls C.A.	4.49	6.21	9.97	11.83	13.09	15.86

APPENDIX Q

NORMS OF

APPENDIX Q

A COMPARISON OF THE OLSON HEIGHT NORMS OF GIRLS WITH THE CURVE OF CONSTANTS OF THIS STUDY

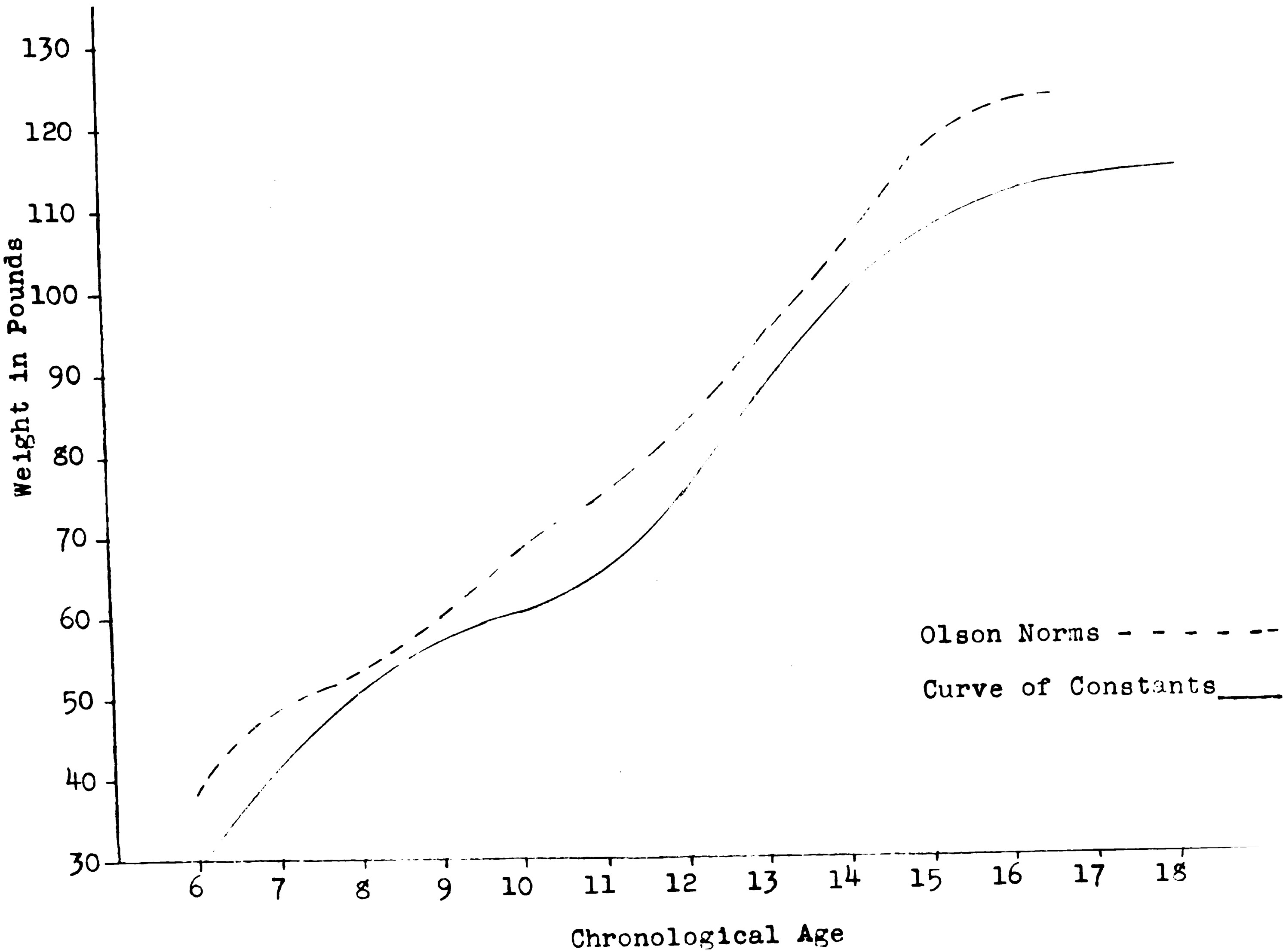


APPENDIX B

NORMS OF

APPENDIX R

A COMPARISON OF THE OLSON WEIGHT NORMS OF GIRLS WITH THE CURVE OF CONSTANTS OF THIS STUDY



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