AGE CHANGES IN YOUNG ADULT ARMY MALES*

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INTRODUCTION

WE have become so accustomed to thinking of growth as being a process which is involved in the production of the adult that it is extremely difficult to define properly the terminology which should apply to changes which occur after the individual has reached a stage commonly referred to as adult. Adulthood, in itself, is subject to a wide variety of interpretations, in that physiological, psychological, and physical fulfillments may be attained at widely divergent chronological periods. The physiological and psychological aspects may be considered as outside the province of this presentation, which will be confined to the physical aspects of development. The studies described by Gray and Ayers (1931), Simmons (1944), and that of the Bureau of Home Economics of the Department of Agriculture (O'Brien and Girshick, 1939) have all terminated at about age 17, with various statements being made in the publications that 17 was considered more or less terminal in the chronological sequence of growth. However, in plotting curves of various dimensions taken on these groups, there is a considerable amount of evidence that some increase, although admittedly slight, still is present. The slopes of the curves plotted vary for different dimensions, so it may be concluded that a given period for the cessation of growth does not exist, but rather that an extended period of time may be required for all the different portions of the body to have completed their development. This fact is certainly not new, inasmuch as roentgenographic studies have clearly shown that bone growth ceases at different ages for different bones. The length of time beyond age 17 during which increases still occur which may be related to growth has not been clearly demonstrated. How much effect, for instance, does the failure of the vertebral epiphyses to close until age 25 have on the

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stature of men? Or, disregarding epiphyseal union, when is the maximum stature of American males attained? Is it statistically sound to compare a group of young adults between ages 20 and 24 with another group between 22 and 26 years of age? Once adult stature is reached, is there a period of stability maintained during which it is possible to group young adult males into age groups which would make them mutually comparable? The importance of these questions to the study of human biology is obvious. Would, for example, young men of ages 17, 18, and 19 have the same distributions of bodily dimensions as would young men of ages 20, 21, and 22?

THE POPULATION

In order to answer the question posed above, a population of young men was studied. The total series consisted of 17,341 Army men, distributed over the entire United States in a close approximation to the manner shown in the U. S. Census Report for 1940. In this series there were approximately 3,000 each of ages 17, 18, and 19; 1,500 of ages 20 and 21; and 1,000 of ages 22, 23, 24, 25, and 26. Owing to the wide distribution over the United States, and to the medical acceptability of the men involved, in so far as the Army was concerned, the series may be considered representative of the healthy American male white adult to a great extent. The men in ages 17 and 18 were just being inducted into the Army, and were without previous military experience; those between 19 and 26 were being separated from the Army, and had received from 12 to 24 months military service. Consequently, we should keep in mind that some differences might occur between 18 and 19 which were a result of the military environment. In all cases, the age given is that of the last birthday of the individual, thus, age 25 includes men between 25 and 25 years and 364 days.

THE DIMENSIONS

The dimensions which will be considered are as follows:

Stature	Inseam
Weight	Stature – inseam
Head circumference	Hand length
Neck circumference	Hand breadth
Sleeve length	Foot length
Chest circumference	Ball foot circumference
Waist circumference	

A brief definition of the methods of measurement of those dimensions not of use in usual anthropometry is in order. Sleeve length is obtained by placing the upper arm of the subject in a horizontal position, at an angle slightly forward of the transverse axis of the trunk, and the forearm at a 30 to 45 degree angle to the upper arm. The measurement, taken by tape, extends from cervicale to stylion with the tape passing over the olecranon process. Waist circumference is taken by tape horizontal to the floor at a level halfway between the lower costal margin and the iliac crests. Neck circumference is obtained with the tape just below the thyroid cartilage. Inseam, taken by anthropometer, extends from the nude crotch to the floor. Ball foot circumference is taken, by tape, over the heads of the metatarsals. Mean values of these dimensions for each of the age groups are listed in Table 1.

COMPARISON OF MILITARY SERIES WITH BRUSH FOUNDATION SERIES

A brief comparison with growth studies already in the literature will serve to establish a point of reference. The stature and weight curves of the Brush Foundation (Simmons, 1944) will be used. The stature of this group (Fig. 1) showed a decline in the rate of increase between 15, 16, and 17, with the maximum, 1765 mm. being reached at age 17. The military series, at age 17, was slightly over 1724 mm. tall, with a maximum being attained at age 23 at nearly 1751 mm. Stature, therefore, increased slowly between 17 and 23, with a very slight decrease being noted thereafter.

The weight (Fig. 2) of the Brush series was also high, reaching a mean of 147.5 pounds, with a decrease in rate of increase appearing after age 15. However, the 17- and 18-year-old age groups in the military series were considerably below this value, 139.5 and 144.0, respectively. The interesting point to note, here, is that age 19, having had military service, has a mean weight which is more nearly on the curve of the Brush series than it is on the U. S.-wide increase rate as indicated by ages 17 and 18. Realizing that the Brush series was made up, to a great extent, of "well-born" children, who should have received good nutrition, whereas the military 17- and 18-year groups were of general United States origins, the position of the 19-year group gains significance. The first conclusion which might be drawn is that the military diet and environment is beneficial to the group, at least so far as weight gain is concerned. Secondly, and of interest from the human biologist's standpoint, it would appear that the general popula-

TABLE 1

Mean values of certain dimensions, for ages 17–26, American males, white, military

	INDUCTEES		SEPARATEES							
	17	18	19	20	21	22	23	24	25	26
Weight	139.26	144.11	151.16	151.91	153.30	155.17	156.05	157.16	157.33	157.87
Stature	172.42	173.81	173.81	173.48	173.86	174.35	175.06	174.50	174.19	174.29
Head circumference	56.03	56.31	56.62	56.62	56.67	56.74	56.74	56.85	56.82	56.85
Neck circumference	35.23	35.69	36.42	36.50	36.63	36.83	36.88	36.98	36.93	37.03
Sleeve length	80.64	81.28	81.15	80.87	81.28	81.66	81.38	81.36	81.28	81.86
Chest circumference	87.63	89.31	90.86	91.14	91.77	92.38	92.74	93.09	93.34	93.37
Waist circumference	73.18	74.60	75.64	75.95	76.78	77.44	77.95	78.54	78.74	79.20
Inseam	84.20	84.73	83.77	83.54	83.49	83.79	83.52	83.74	83.49	83.49
Stature – inseam	88.37	89.23	90.20	90.07	90.50	90.73	90.70	90.88	90.83	90.91
Hand length	19.20	19.28	19.23	19.23	19.33	19.41	19.35	19.41	19.33	19.35
Hand breadth	8.61	8.66	8.61	8.69	8.76	8.81	8.79	8.79	8.79	8.79
Foot length	26.42	26.54	26.54	26.49	26.52	26.59	26.57	26.59	26.54	26.57
Ball circumference	24.61	24.66	24.59	24.59	24.74	24.79	24.71	24.74	24.69	24.71
Number	3166	3190	3016	1500	1369	1191	1023	902	981	1003

All dimensions are in centimeters, except for weight, which is in pounds.

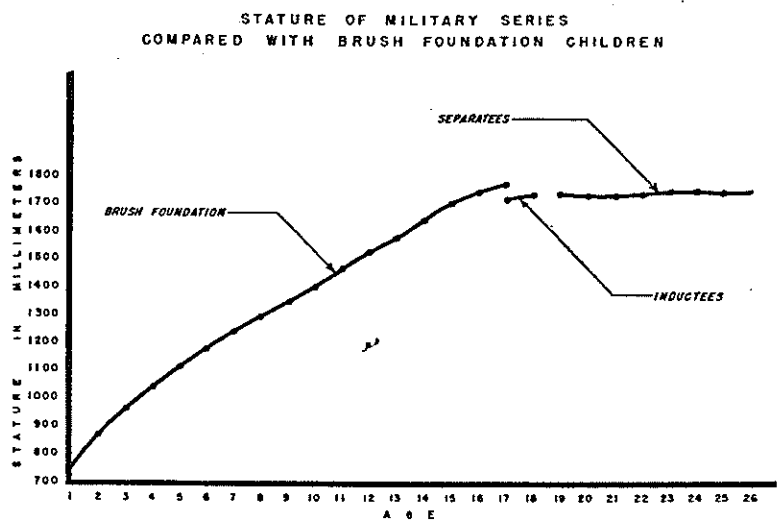

FIG. 1. STATURE OF MILITARY SERIES COMPARED WITH BRUSH FOUNDATION CHILDREN

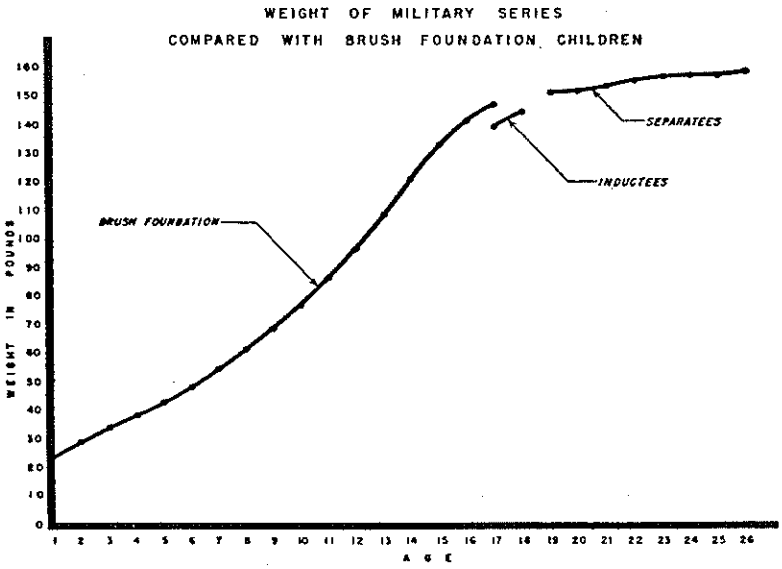

FIG. 2. WEIGHT OF MILITARY SERIES COMPARED WITH BRUSH FOUNDATION CHILDREN

tion is capable of at least as much expression of weight as is that of a "well-born" category if it is given the opportunity. Recalling one of the questions posed in the introduction concerning the mutual comparability of age groups, this difference noted, which is apparently a result of environment, is indicative of the problems which continually arise in the statistical definition of populations.

RATES OF CHANGE BETWEEN 17 AND 26

All the dimensions studied show changes between 17 and 26. All except one show a positive increase, with inseam being the only one to show a decrease. The greatest change, as might be expected, occurs in weight, which increases from 139.26 pounds at age 17 up to 157.87 pounds at age 26. Next, as might also be expected, is the waist circumference, which increases from 73.2 cm. at 17 to 79.2 cm. at 26. Chest circumference is not far behind, increasing from 87.6 cm. to 93.4 cm. between 17 and 26. Also involved in the soft tissue increase is the neck circumference, which increases from 35.2 cm. at 17 to 37.0 cm. at 26. However, the neck appears to stabilize in the 24th year. Weight and waist circumference are still showing small increases at age 26, but the slopes are so low as to indicate that the maximum is nearly attained.

If these dimensions are placed on a comparative basis by setting age 17 as a 100 per cent level of attainment (Fig. 3), weight will be noted to have increased to 113.36 per cent, waist circumference to 108.23 per cent, chest circumference to 106.55 per cent, and neck circumference to 105.12 per cent of the 17-year level by age 26. In all these cases, it should be noted that the final attainment based on age 17 is not quite valid, inasmuch as ages 17 and 18 were not of previous military service. In weight, for example, age 19 is 108.55 per cent of age 17. In other words, an increase from 100.00 per cent to 108.55 per cent between 17 and 19, and a subsequent increase from 108.55 per cent to 113.36 per cent between 19 and 26 do not form a valid curve. If the latter portion of the curve were projected backward to age 17, in an effort to compensate for the two different environments, age 17 might very well be 105 to 106 per cent of what it was found to be, which would reduce the final weight achieved by age 26 to 107.5 per cent. This would, of course, change the final result for the girth measurements.

Changes which are basically a result of bony growth show a somewhat different picture. Stature reaches its maximum, in this series, at age 23, 175.1 cm. Even though the mean values indicate a maximum

attained at age 23, there is no statistically significant change after age 18. Consequently, evidence is strong that the American white male attains his adult stature, as an average, in the 18th year.

Inseam, composed almost entirely of linear portions of the lower extremities, shows a slight decrease, but this is apparently a result of two factors; one, the deposition of fat in the perineum, and two, an increasing difficulty in obtaining a good crotch approximation with the

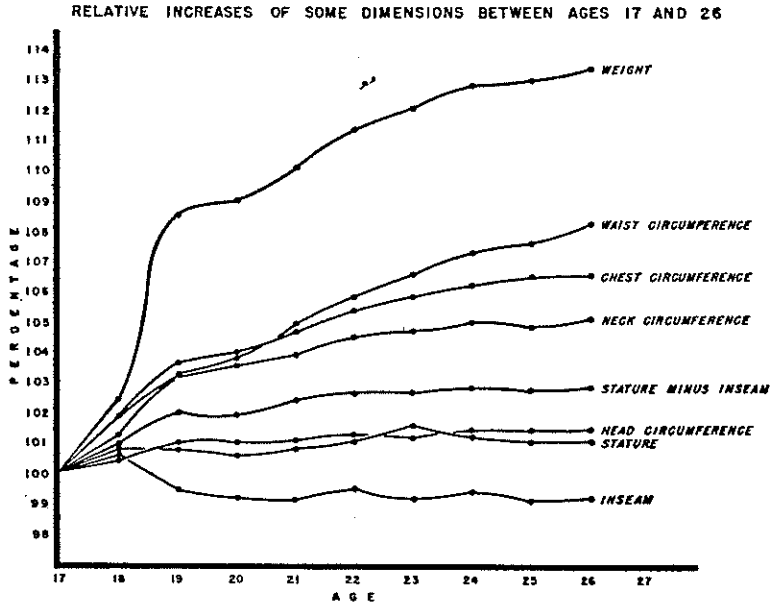

FIG. 3. RELATIVE INCREASES OF SOME DIMENSIONS BETWEEN AGES 17 AND 26

bar of the anthropometer because of increasing fat deposition on the medial aspects of the thigh near the crotch. Stature minus inseam, however, shows a rather marked increase between 17 and 24, primarily between 17 and 20. This final "growth" may be a result of epiphyseal growth just prior to closure of the vertebral epiphyses at about age 25, or may also be a result of more erect postures.

Head circumference shows its last growth phase between 17 and 19, with a slow, persistent trend producing another .1 inch by age 24. There are no indications that the continued growth occurs in the manner which Hrdlicka (1936) described.

Of the four dimensions of the extremities (Fig. 4), the only one which shows any increase after 17 is the hand breadth, which increases two per cent between 19 and 22. This possibly is connected with the weight increase, but may also be a result of muscular conditioning of the hand, since the heads of the metacarpals have closed by the 19th year.

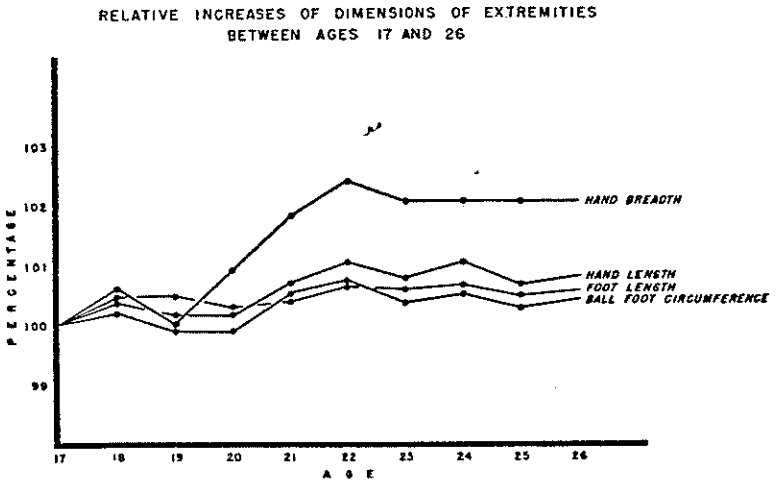

FIG. 4. RELATIVE INCREASES OF DIMENSIONS OF EXTREMITIES BETWEEN AGES 17 AND 26

PAIRED RELATIONSHIPS

Quite often a discussion confined to mean values of separate dimensions may produce a very misleading understanding of the situation which actually exists in a population. To say that stature is constant after age 18 but that weight continues to increase is one thing, but this statement hasn't answered very much of the question. Certainly, beyond this straightforward statement is a further question. What is the relationship of weight to stature as regards their variabilities throughout the period which is being considered? It might be assumed, at first, that a general consistency of relationship exists over the period which might be termed young adult.

In order to introduce this consideration, a reference to the Brush

series (Fig. 5) will be in order. The sequence of the correlation coefficients between 1 and 17 years in the Brush series shows that the value of r begins at .625, increases rather rapidly to about .750 at age 3, remains at that level until 13 or 14, then decreases again to .650 at 17. In the military series, the r value at age 17 is .510, with a steady decrease occurring through the period studied, reaching .410 at age 26. Only during ages 19, 20, and 21 does it remain rather stable at .490. From these observations, it might be concluded that the relationship of weight to stature becomes less and less after age 14, at least through age 26 (Fig. 6). Since r becomes less during successive ages in the military

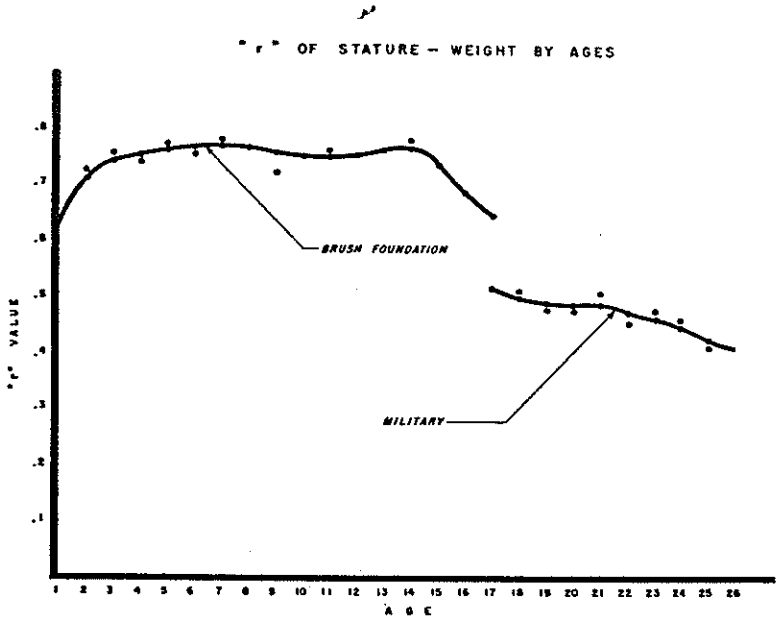

FIG. 5. AGE CHANGES IN CORRELATION BETWEEN STATURE AND WEIGHT

series, the regression equation, weight $= a + b \cdot$ stature, showing the relation of weight to stature, naturally changes, with the slope of the regression (b) of weight on stature decreasing and the y (weight) intercept increasing, as shown in Fig. 6.

From these observations, it would appear that, in so far as weight and stature are concerned, there is only a brief period between 19 and 21 which might be considered at all stable.

Since it was found that weight became increasingly variable in its relation to stature, it should not come as a surprise that chest circumference (Fig. 7) follows the same pattern in its relation to stature. The

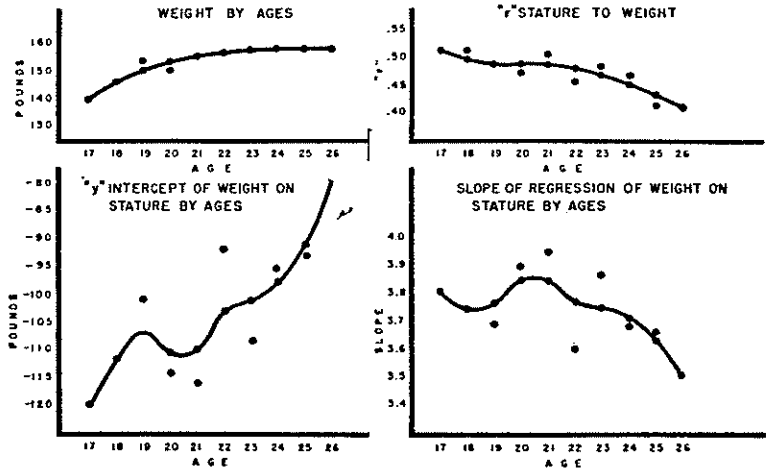

FIG. 6. RELATIONS OF WEIGHT TO STATURE BETWEEN AGES 17 AND 26

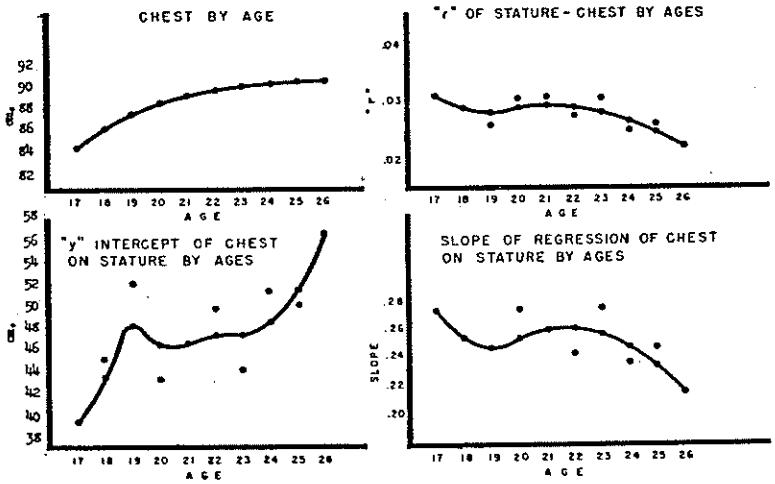

FIG. 7. RELATIONS OF CHEST CIRCUMFERENCE TO STATURE BETWEEN AGES 17 AND 26

value of r decreases along a convex curve, remaining rather stable between 17 and 21.

Here, then, are examples of situations which serve to confuse that aspect of cessation of growth referred to earlier. Certainly it is clear that cessation is subject to question in its definition in regard to the entire body.

The relation of hand breadth to hand length is the only one which has apparently stabilized by age 17, but even here, although r remains constant, the hand breadth does increase between 17 and 21.

The final relationship studied (Fig. 8) is that between foot length and

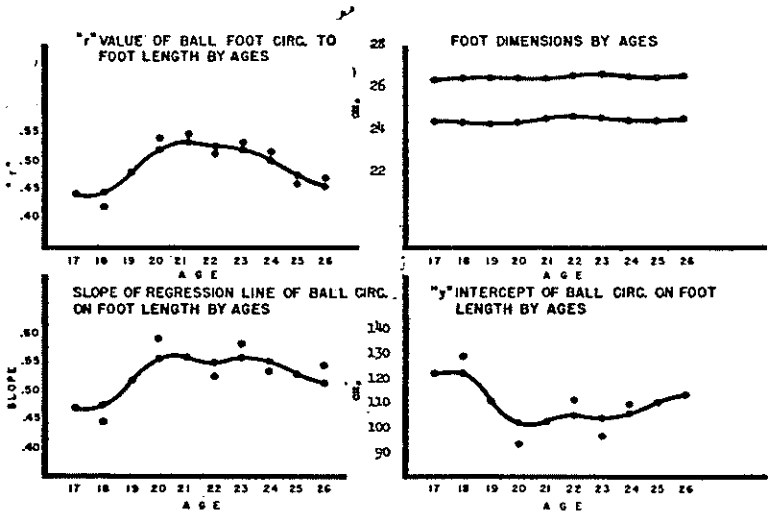

FIG. 8. RELATIONS OF FOOT DIMENSIONS BETWEEN AGES 17 AND 26

ball foot circumference. The r value is highest between 20 and 23 where it may be considered rather stable. The interesting point to be noted here is that both the length and the circumference remain stable in dimension following age 18. Even so, r at 26 is only slightly above the 17- and 18-year values.

CONCLUSIONS

It should be clear that we are dealing with a range of years over which some portions of the body have ceased growth, while others are still involved in increase in dimension, even though we may not fully agree

on terming this increase growth. Since the increase is open to question in its definition, the logical conclusion then must be that the definition of growth must come under new consideration. Certainly, the difference in the terms of increase in dimension and growth is subtle, but this very subtlety must be realized before clarification of the terms can be attained. One possible way out of this dilemma is to segregate the concepts into two categories: the cessation of skeletal growth as defined by the closure of epiphyses; and the cessation of growth or increase in dimension of the soft tissues. One objection to this type of consideration is that increasing age, decrease of muscular tonicity, and physical conditioning may all be contributory to a change in dimension which is not a result of growth. Waist circumference would be notable in this respect.

From the standpoint of the *human biologist,* the variability of successive age groups should certainly serve as a warning to exert extreme care in the weighting of populations for comparative purposes. A common practice, for example, has been to group series into five-year periods, 20-25, 25-30, 30-35, etc., which, on the surface appears quite acceptable. However, if the proportions of ages within the sub-groups differ to any marked degree, highly spurious results may be expected.

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