A Modified Somatotype Method [1]

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ABSTRACT A new and improved somatotype method with universal application to both sexes, for all ages and which is reproducible, is justified, validated and described. Evidence is presented for extension of previous component rating scales. Data on 844 male and female subjects from selected samples were used to develop and validate anthropometric scales for estimating the Heath component ratings. The definitions and rating procedures for the new somatotype method are presented, with descriptions of the anthropometric somatotype and the combined photoscopic and anthropometric somatotype.

The purpose of this paper is to present a somatotype method suitable for description of individual variation in the human species. To this end, we have adopted universal rating scales and criteria which apply to both sexes at all ages.

We present a somatotype method which consists of Heath's ('63) modifications and adaptations of Parnell's ('58) M.4 technique, which Heath and Carter ('66) explored. We report the rationale for extending and readjusting the rating scales, and have constructed tables to use with the Heath somatotype method. The extended and readjusted rating scales together with these tables also enable investigators to obtain reliable anthropometric somatotype ratings.

There are many somatotype studies which include extremes in one or more of the three somatotype components. We have carefully studied several of these which emphasize the importance of using *one* method suitable for *all* investigations. Seltzer's ('64) study of obese females discusses the problem of adequate differentiation of a series in which the majority are rated seven in the first component (endomorphy), when the criteria of Sheldon's seven-point scale are applied. In the British Empire and Olympic Games series described by Tanner ('64), there are athletes from many countries who are rated seven rating units (*seven*) in the second component (mesomorphy) by Sheldon's criteria; but they are conspicuously more mesomorphic than the examples of second component *seven's* in ATLAS OF MEN (Sheldon, '54). Heath found many males among the Manus in the Admirality Islands (Mead) who cannot reasonably be rated by Sheldon's second component criteria. Roberts and Bainbridge ('63) found it necessary to modify the Sheldon scale to fit the height/$\sqrt[3]{\text{weight}}$ ratios obtained in their study of the physiques of Nilotes. Third component ratings of *seven* were not adequate for description and differentiation of the Nilote Series, in which there was a high incidence of extremes in ectomorphy. Irrespective of age and nutritional status, uniquely high third component ratings were confirmed by limb length and low total skinfold measurements as well as by height/$\sqrt[3]{\text{weight}}$ ratios higher than any reported by Sheldon. Heath has also found high extremes in the first component and low extremes in the third component in studies of growth and development (Walker, '62); and significant changes in somatotype ratings from year to year are common for subjects in the Medford Growth Study (Clarke, '63). There is good evidence that selected samples in this country and elsewhere will continue to reveal somatotypes which do indeed emphasize the need for a somatotype method to describe all human variation.

Sheldon's ('40, '54) concept of quantifying "three primary morphological components" is original, useful and important. Despite lingering semantic problems, the

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four coined words — somatotype, endomorphy, mesomorphy, ectomorphy — are widely accepted in our vocabulary. They seem to convey reasonably similar and defensible meanings to those who use them. Standardized somatotype photographs, accurately measured and recorded stature, weight, and age are essential to precise description of human physical variation by means of somatotyping. However, a number of investigators have found the definitions, criteria, and interpretations in Sheldon's publications unsatisfactory. Several investigators (Cureton, '47; Hooton, '51; Parnell, '54, '58; Damon et al., '62; Sheldon, unpublished) have proposed various adaptations and modifications of somatotype method, but none of these has overcome the fundamental limitations. Heath ('63) proposed modifications to overcome some of the shortcomings of existing systems. During the past 12 years Heath has applied these modifications to somatotype data involving approximately 15,000 ratings, which have been used in over 30 published studies. The studies include work associated with the Institute of Human Development in Berkeley, the Gesell Institute, Harvard University, the Medford Growth Study, Institute of Child Health in London, University of Hawaii, San Diego State, the American Museum of Natural History, Ochanomizu University in Tokyo, and the Institute of Anthropology in Moscow. The subjects studied include longitudinal and cross-sectional data for both sexes at all ages. There are large samples of U. S. and English populations. There are also substantial samples of Eskimos, Japanese, Manus (Admiralty Islands), and athletes from 11 countries.

Because the Heath method has already been widely applied, it is now necessary to state the concepts and procedures of the method together with recently added objective elements. This statement distinguishes the method from other methods, and facilitates comparative studies.

EXTENSION OF SOMATOTYPE COMPONENT SCALES

Heath ('63) indicated that component scales should be open-ended in order to accommodate variations greater than those observed in Sheldon's ('40) pilot studies. She studied selected series of somtatype photographs to establish extentions of the scales and to accomodate extremes in all three somatotype components. Series which included three skinfold measurements — triceps (t), subscapular (ss), suprailiac (si), — were rerated, relying primarily upon inspection and Heath's ('63) table of somatotypes and height/$\sqrt[3]{\text{weight}}$ ratios, but considering relationships between total skinfold measurements and first component ratings.

The first sample consisted of 102 obese females (Seltzer, unpublished). First component ratings ranged from *5.0* to *19.0*, without consideration of skinfold measurements. Although the first component ratings remained high, the range was from 5.5 to *12.0* when skinfold measurements were considered. The rerating changes are shown in table 1. This tabulation shows that in almost 80% of cases there were *no* rating changes in the second component, and in 99% there were no changes greater than *plus-or-minus one-half*. In more than 92% of cases there were *no* changes in the third component greater than *one-half*. But in almost 79% of cases there were first component changes which lowered the ratings by *one-half* to *seven*.

Similar procedures were applied to selected portions of the British Empire and Olympic Games series (Tanner, '64) and of the Manus series of males (Mead). These subseries were chosen because of the high incidence of height/$\sqrt[3]{\text{weight}}$ ratios below 12.20 and low skinfold totals. The differences in means between the first and second ratings are as follows:

Athletes	*1st comp.*	*2nd comp.*	*3rd comp.*
First rating	3.25	6.28	1.57
Second rating	2.08	6.99	1.34
Manus			
First rating	2.32	6.50	1.60
Second rating	1.64	6.71	1.63

The data in table 1 reflect the differences in patterns of rating changes in series in which skinfold totals are high with correspondingly high first component ratings, and in series in which skinfold totals are low with high second component ratings. The magnitude of first component changes is of course greatest in the obese series. Although the means for total skin-

TABLE 1

Rating changes in three series of extreme somatotypes

First component			Second component			Third component		
Change	Freq.	%	Change	Freq.	%	Change	Freq.	%
			A. Obese women (Seltzer, unpub.)					
+0.5	7	6.8						
0.0	15	14.7						
−0.5	9	8.8						
−1.0	11	10.8						
−1.5	12	11.8						
−2.0	14	13.7						
−2.5	8	7.8						
−3.0	6	5.9						
−3.5	5	4.9						
−4.0	3	2.9						
−4.5	4	3.9						
−5.0	2	1.9	+0.5	7	6.8			
−5.5	3	2.9	0.0	78	77.5	+0.5	5	4.9
−6.0	2	1.9	−0.5	16	15.7	0.0	94	92.2
−7.0	1	1.0	−1.0	1	1.0	−0.5	3	2.9
	102	99.9		102	100.0		102	100.1
			B. Olympic and Empire Games atheletes (Tanner, '64)					
+1.5	9	14.15						
+1.0	1	1.6						
0	6	9.7	+2.0	1	1.6	+1.0	1	1.6
−0.5	15	24.2	+1.5	7	11.3	+0.5	1	1.6
−1.0	21	33.8	+1.0	15	24.2	0	32	51.5
−2.0	6	9.7	+0.5	27	43.5	−0.5	26	41.8
−2.5	4	6.4	0	12	19.3	−1.0	2	3.2
	62	99.9		62	99.9		62	99.7
			C. Manus males (Mead, unpub.)					
0	9	25.9	+1.5	1	2.9	+1.0	1	2.9
−0.5	11	31.4	+1.0	4	11.4	+0.5	5	14.3
−1.0	10	28.5	+0.5	13	37.1	0	16	45.8
−1.5	3	8.6	0	17	48.5	−0.5	8	22.6
−2.0	2	5.7				−1.0	5	14.3
	35	99.9		35	99.9		35	99.9

folds are similar for the athletes and for the Manus, 94% of the Manus skinfold totals range from 11.0 to 18.9 mm, while only 45% of the athletes have skinfold totals in this low range. Therefore the greater changes in first and second component ratings in the athletes' series were expected.

While the range of final second component ratings for the two male series was from 5.0 to 9.5, it is noteworthy that of the combined total of 97 ratings, 37 ratings are higher than any reported in ATLAS OF MEN. On this basis, it is apparent that both skinfold values and height/$\sqrt[3]{\text{weight}}$ ratios (as well as inspectional impressions) support ratings higher than *seven* in the second component.

Detailed analysis of the rating changes made in the TOPS series of obese women and those made in the subseries of athletes and in the Manus series is presented because these three subgroups include the most extreme somatotype ratings we have observed. These series offered an unusual opportunity to test two empirical scales for their value and validity in objectifying somatotype method. This analysis also suggested that it is desirable to readjust the height/$\sqrt[3]{\text{weight}}$ ratio distribution by widening the intervals for *one*-rating changes at the low end of the scale; that it is feasible to extend the rating scales upward for the first and second components; and that total skinfold values are acceptable for rating the first component. It also developed that *one-half* ratings at the low end of the third component scale helped to differentiate some subjects in these series and in studies of young cihldren (Walker, '62). Furthermore, Roberts and Bainbridge ('63) found that ratings of *eight* and *nine* in the third component were appropriate for the 11.7% of their Nilotic sample whose height/$\sqrt[3]{\text{weight}}$ ratios were above 14.80.

In other words, it became evident that anthropometric measurements, such as total skinfold values, can be used to increase the objectivity and reliability of somatotype ratings, and as guidelines in extension and readjustment of rating scales.

DEVELOPMENT OF ANTHROPOMETRIC SOMATOTYPE SCALES

Both Heath's and Sheldon's somatotype methods have required long training because inspectional skill is crucial to reliable rating. The apparent interrelationships among skinfold measurements, total body fat, and first component ratings suggested the possibility of developing anthropometric somatotype scales which could be matched with the Heath method, thereby improving reliability and reproducibility of somatotype rating.

We used data for 844 subjects to develop anthropometric scales for estimating the component ratings by the Heath method. Of the 844 subjects, we had suitable anthropometric data together with standard somatotype photographs for 597, and anthropometric data only for 247 subjects. In addition to age, height, and weight, the anthropometric measurements consist of sums of skinfolds — t, ss, and si measurements — and in some cases diameters of humerus and femur, muscle girths of calf and biceps, and calf (c) skinfolds. The ages range from 14 years to the seventies; they represent many countries, races and racial combinations; they include extremes in each of the somatotype components, and a wide range of total skinfold measurements. The subject's series were as follows:

1. British Empire Games and Olympic Games athletes (Tanner, '64).
   N = 166.
   Males from 23 countries.
   Ages 17 to 37 years.
   Three skinfolds (t, ss, si), measured on left side, with Harpenden caliper.
   Weight in kilograms and tenths, height in millimeters.
   Standard somatotype photographs.
2. Teachers and students of physical education, New Zealand (Carter, '64, '65).
   Males and females.
   N = 65 males, 66 females.
   Ages 18 to 52 years, males; ages 18 to 39, females.
   Three skinfolds (t, ss, si), measured on right side, Harpenden caliper.
   Weight in pounds, height in inches and tenths.
   Standard somatotype photographs.
3. American college and university students (Haronian and Sugarman, '65).
   Males.
   N = 102.
   Ages 17 to 28 years.
   Three skinfolds (t, ss, si), measured with Lange caliper. Side measured, not reported.
   Weight in pounds, height in inches and tenths.
   Standard somatotype photographs.
4. San Diego State (SDS) businessmen and teachers.
   Males (Carter, unpublished).
   N = 19.
   Ages 28 to 59 years.
   Three skinfolds (t, ss, si), measured on right side, Harpenden caliper.
   Weight in pounds, height in inches and tenths.
   Standard somatotype photographs.
5. TOPS series (Seltzer, unpublished data). Obese American females.
   Females.
   N = 102.
   Ages 17 to 69 years.
   Two skinfolds (t, ss), with Lange caliper. Side measured, not reported.
   Weight in pounds, height in millimeters.
   Standard somatotype photographs.
6. Manus series (Mead, unpublished data).
   Males and females.
   N = 35 males, 42 females.
   Ages 18 years to seventies.
   Three skinfolds (t, ss, si), measured with Harpenden caliper, on left side.
   Standard somatotype photographs.
7. Special series (Carter, unpublished data).
   (a) Teacher, housewives, students, and athletes, primarily from the San Diego area.
   Females.
   N = 196.
   Ages 14 to 69 years.
   Three skinfolds (t, ss, si), measured on the right side, Harpenden caliper.
   No photographs.
   (b) Physical education majors, San Diego State.
   Females.
   N = 19.
   Ages 21 to 27 years.

Four skinfolds (t, ss, si, c), measured on right side, Harpenden caliper.
No photographs.

(c) U. S. Navy, Underwater demolition trainees, San Diego.
Males.
N = 32.
Ages 17 to 31 years.
Four skinfolds (t, ss, si, c), measured on right side, Harpenden caliper.
No photographs.

First component

The first step in constructing a suitable scale (derived from skinfold values) to match Heath inspectional ratings was in establishing the relationship, if any, between sums of three skinfolds (t, ss, si) and the Heath ratings.

There were available first component ratings on 501 male and female subjects, ages 16 to 69 years (series nos. 1, 2, 3, 5). Ratings were made prior to including skinfold values in the rating method. The TOPS series (no. 5) is particularly important because of the uniquely high first component ratings and uniquely low height/$\sqrt[3]{\text{weight}}$ ratios, and because of the high skinfold measurements. In order to compare this series with the others, the data required special analysis because t and ss skinfolds only were measured. The sums of the two skinfolds is higher for the majority of these subjects than the sums of the three skinfolds measured in the other series.

In order to estimate the average contribution of si skinfold measurements to skinfold totals of three skinfolds, data on skinfold measurements for 262 females, ages 14 to 69 years were used. These included the New Zealand series (no. 2) and the special series (no. 7a). For the combined series total skinfold measurements ranged from 15.8 mm to 113.3 mm, si measurements ranged from 4.3 mm to 43.1 mm. The mean for the si measurements was 13.3 mm, or 30.9% contribution of si measurements to the total of three measurements. Based upon the above estimate of percentage contribution of si skinfold measurements to total measurements the TOPS series total skinfolds range from 55 mm to 157 mm, with a mean of 97.3 mm.

Using the paired data from the 501 subjects the product-moment correlation was r = 0.95. This relationship indicates that Heath first component ratings and skinfold scores were so similar that a skinfold score substituted for a Heath rating would sacrifice little or no accuracy, especially in group studies. Furthermore the test-retest reliabilities for skinfold measurements are 0.90–0.96, and test-retest reliabilities for Heath ratings are approximately 0.92. It is therefore unlikely that a higher correlation could be obtained.

Figure 1 shows in graphic form the essentially linear relationship between first component ratings and skinfold totals for the combined male and female series. The medians were plotted, because at some rating points the distributions appeared slightly skewed. Inconsistencies between *one-half* ratings shown in figure 1 may be due in part to one or more of the following factors: (1) Use of different calipers in different series; (2) measurements made on the right side in some series, on the left in others; (3) first component ratings made by Heath at different times; (4) possible differences in reliabilities of measurements, especially in the case of high skinfold totals; (5) small numbers of observations for some rating values; and perhaps most important, (6) limitations in the Heath ('63) height/$\sqrt[3]{\text{weight}}$ ratio table for very low ratios. This last point indicated that the distribution of somatotypes and height/$\sqrt[3]{\text{weight}}$ ratios required modification — especially for ratios lower than 12.00.

A scale for obtaining first component ratings from total skinfolds was constructed, employing the following points as guidelines:

1. Skinfold distributions are positively skewed.
2. Heath's first component scale is positively skewed.
3. Small increments in skinfolds are easily observed on inspection of photographs of subjects low in the first component; but small increments in skinfolds are not easily observed in subjects high in the first component. In other words, the percentage of increment in total skinfolds becomes more important than absolute increments in cases of high first component ratings.
4. If reasonable error in total skinfold measurements is ± 5%, then increments

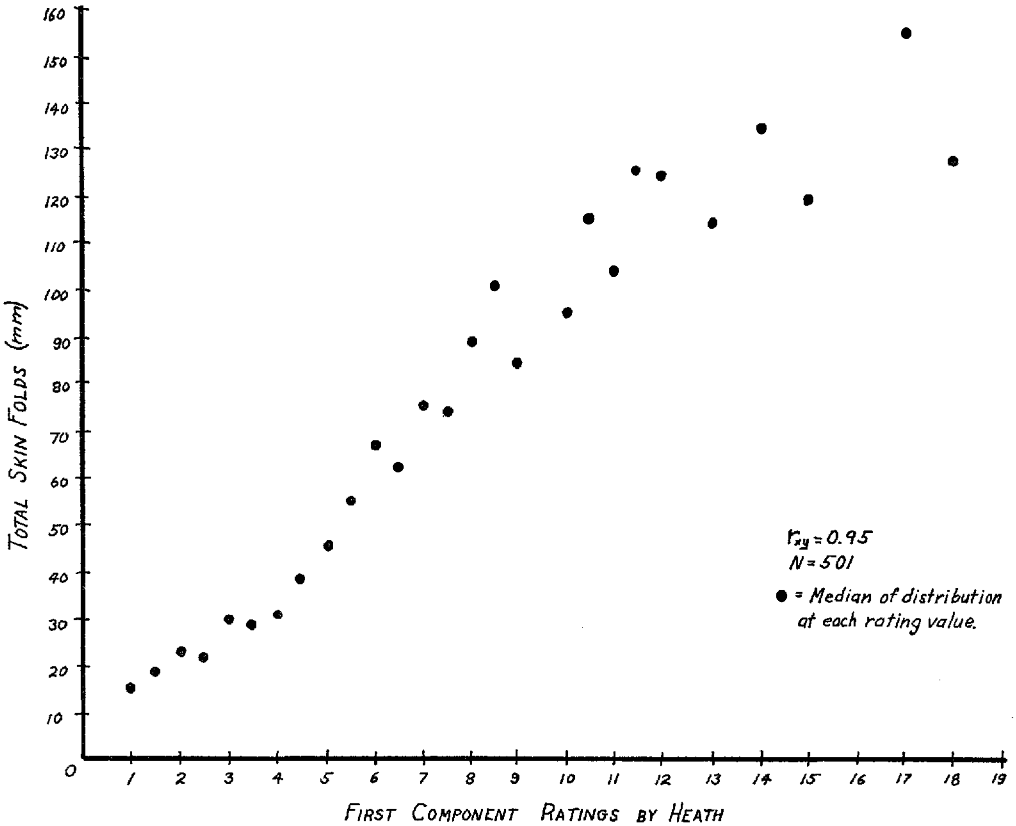

Fig. 1 First component ratings by Heath versus sum of three skinfolds (triceps, subscapular, suprailiac).

between rating units for the first component must be 10% or more of total skinfolds.

5. In constructing a scale of total skinfolds the increments between first component rating units should be established so as to meet the criterion of locating 90% or more of the component ratings within plus-minus *one-half*.

6. Since the specific gravity of fat is lower than that of bone, muscle and other body constituents, a greater volume of fat is required for increases in weight and corresponding decreases in height/$\sqrt[3]{\text{weight}}$ ratios.

The scale so constructed is shown in the upper part of figure 2. The mid-points of the total skinfold values for each first component rating unit are shown in figure 3. The data show that there are increasing amounts of increase in total skinfold values, but decreasing percentages of increase. The lowest percentages of increase lie between *one-half* intervals from ratings of *seven and one-half* and above. Here the percentages lie between 9% and 10%.

Table 2 shows the distribution of somatotypes and height/$\sqrt[3]{\text{weight}}$ ratios, readjusted so that intervals between *one* rating changes are greater for ratios lower than 12.00. At the same time the upper end of the table was reviewed for accommodation of subjects with unusually high

Fig. 2 The Heath-Carter somatotype rating form. The F-scale for arriving at the first component rating is the upper scale. The M-scale for arriving at the second component rating is the middle scale. The L-scale for arriving at the third component rating is the lower scale. Data and procedures for arriving at an anthropometric somatotype 4–5–2½ are illustrated.

HEATH-CARTER SOMATOTYPE RATING FORM

NAME: J.B. AGE: 45-2 SEX: (M) F NO: 135

OCCUPATION: Teacher ETHNIC GROUP: Caucasian DATE: 11 Nov 1966

PROJECT: A.T.P. MEASURED BY: L.C.

Skinfolds (mm):

- Triceps = 13·0
- Subcapular = 15·3
- Supraliac = 9·9
- TOTAL SKINFOLDS = 38·2
- Calf = 9·8

TOTAL SKINFOLDS (mm)

Upper Limit	10.9	14.9	18.9	22.9	26.9	31.2	35.8	40.7	46.2	52.2	58.7	65.7	73.2	81.2	89.7	98.9	108.9	119.7	131.2	143.7	157.2	171.9	187.9	204.0
Mid-point	9.0	13.0	17.0	21.0	25.0	29.0	33.5	(38.0)	43.5	49.0	55.5	62.0	69.5	77.0	85.5	94.0	104.0	114.0	125.5	137.0	150.5	164.0	180.0	196.0
Lower Limit	7.0	11.0	15.0	19.0	23.0	27.0	31.3	35.9	40.8	46.3	52.3	58.8	65.8	73.3	81.3	89.8	99.0	109.0	119.8	131.3	143.8	157.3	172.0	188.0
FIRST COMPONENT	½	1	1½	2	2½	3	3½	(4)	4½	5	5½	6	6½	7	7½	8	8½	9	9½	10	10½	11	11½	12

- Height (in.) = 67·1
- Bone: Humerus (cm) = 6·84
- Femur = 9·27
- Muscle: Biceps 33·0 (cm) −1·3 − (triceps skinfold) = 31·7
- Calf 35·1 − (calf skinfold) ·98 = 34·1

55.0	56.5	58.0	59.5	61.0	62.5	64.0	65.5	↓67.0	68.5	70.0	71.5	73.0	74.5	76.0	77.5	79.0	80.5	82.0	83.5	85.0	86.5	88.0	89.5
5.19	5.34	5.49	5.64	5.78	5.93	6.07	6.22	6.37	6.51	6.65	(6.80)	6.95	7.09	7.24	7.38	7.53	7.67	7.82	7.97	8.11	8.25	8.40	8.55
7.41	7.62	7.83	8.04	8.24	8.45	8.66	8.87	9.08	(9.28)	9.49	9.70	9.91	10.12	10.33	10.53	10.74	10.95	11.16	11.37	11.58	11.79	12.00	12.21
23.7	24.4	25.0	25.7	26.3	27.0	27.7	28.3	29.0	29.7	*30.3	31.0	(31.6)	32.2	33.0	33.6	34.3	35.0	35.6	36.3	37.1	37.8	38.5	39.3
27.7	28.5	29.3	30.1	30.8	31.6	32.4	33.2	(33.9)	34.7	35.5	36.3	37.1	37.8	38.6	39.4	40.2	41.0	41.8	42.6	43.4	44.2	45.0	45.8

SECOND COMPONENT: ½ 1 1½ 2 2½ 3 3½ 4 4½ (5) 5½ 6 6½ 7 7½ 8 8½ 9

- Weight (lb.) = 147·0
- Ht. / $\sqrt[3]{\text{Wt.}}$ = 12·76

Upper limit	11.99	12.32	12.53	12.74	12.95	13.15	13.36	13.56	13.77	13.98	14.19	14.39	14.59	14.80	15.01	15.22	15.42	15.63
Mid-point	and	12.16	12.43	12.64	12.85	13.05	13.26	13.46	13.67	13.88	14.01	14.29	14.50	14.70	14.91	15.12	15.33	15.53
Lower limit	below	12.00	12.33	12.54	(12.75)	12.96	13.16	13.37	13.56	13.78	13.99	14.20	14.40	14.60	14.81	15.02	15.23	15.43
THIRD COMPONENT	½	1	1½	2	(2½)	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½	9

	FIRST COMPONENT	SECOND COMPONENT	THIRD COMPONENT	
Anthropometric Somatotype	4	5	2½	BY: L.C.
Anthropometric plus Photoscopic Somatotype				RATER:

Figure 2

TABLE 2

Distribution of somatotypes on the criterion of height/$\sqrt[3]{weight}$, for both sexes and all ages

Ratio	Somatotypes	
15.40	1–1–9	
15.20	1–1–8	1–2–9
15.00	1–1–7	1–2–8, 1–2½–8½
14.80	1–2–7, 2–1–7	
14.60	1–2–6	2–2–7, 1–3–7
14.40	1–3–6, 1½–3–6½ 2–2–6	2–3–7, 3–2–7
14.20	2–2–5 1½–2½–5	2–3–6, 3–2–6 1½–3½–6
14.00	2–3–5, 3–2–5, 2½–3–5½ 1–4–5, 4–1–5	3–3–6, 4–2–6 2½–3½–6
13.80	3–3–5, 3½–2½–5, 2–4–5, 4–2–5	
13.60	4–2–4, 3–3–4, 2½–3½–4 1–5–4, 2–4–4	2½–4½–5 3–4–5, 5–2–5, 4–3–5
13.40	1–5–3, 1½–5–3½ 4–2½–3½	2–5–4, 3–4–4, 3½–3½–4 5–2–4, 4–3–4, 2½–4½–4
13.20	2–5–3, 5–2–3, 4–3–3, 2½–5–3½ 1½–5½–3, 5–2–3, 1–6–3, 3–4–3	4–4–4 5–3–4, 3–5–4
13.00	6–1–2, 1–6–2 2–5–2, 5–2–2	6–2–3, 2–6–3 4–4–3, 5–3–3 3–5–3
12.80	2–6–2, 4–4–2 7–1–2, 1–7–2, 6–2–2 5–3–2, 3–5–2	6–3–3, 3–6–3 5–4–3, 4–5–3
12.60	7–1–1, 1–7–1, 6–2–1 2–6–1	3–6–2, 5–4–2, 4–5–2 7–2–2, 2–7–2, 6–3–2
12.40	7–2–1, 2–7–1, 6–3–1 3–6–1, 5–4–1, 4–5–1	7–3–2, 3–7–2, 6–4–2 4–6–2, 5–5–2
12.20	7–3–1, 3–7–1 6–4–1, 4–6–1, 5–5–1	6½–4–½ 5½–5–½
12.00	7–4–1, 8–3–1, 9–2–1, 3–8–1 4–7–1, 5–6–1, 6–5–1	6½–4–½, 7½–3–½, 8½–2–½ 2½–8–½, 3½–7–½, 4½–6–½ 5½–5–½
11.70	8–4–1, 9–3–1, 10–2–1 3–9–1, 4–8–1, 5–7–1, 6–6–1	7½–4–½, 8½–3–½, 9½–2–½ 2½–9–½, 3½–8–½, 4½–7–½, 5½–6–½ 6½–5–½
11.40	9–4–1, 10–3–1, 11–2–1 5–8–1, 6–7–1, 7–6–1, 8–5–1	8½–4–½, 9½–3–½, 8–4½–½, 9–3½–½ 4½–8–½, 5½–7–½, 6½–6–½, 7½–5–½ 4–8½–½, 5–7½–½, 6–6½–½, 7–5½–½
11.00	10–4–1, 11–3–1, 10–5–1 8–6–1, 7–7–1, 6–8–1, 5–9–1	9½–4–½, 10½–3–½, 9–4½–½ 8½–5–½, 7½–6–½, 6½–7–½, 5½–8–½
10.50	11–4–1, 12–3–1, 10–5–1 6–9–1, 7–8–1, 8–7–1	10½–4–½, 11½–3–½, 10–4½–½ 5½–9–½, 6½–8–½, 7½–7–½, 8½–6–½ 9½–5–½, 9–5½–½, 8–7½–½
10.00	12–4–1, 13–3–1, 11–5–1, 10–6–1 8–8–1	11½–4–½, 12½–3–½, 11–4½–½ 7½–8–½, 8½–7–½, 9½–6–½ 10½–5–½, 7–8½–½, 8–7½–½, 9–6½–½
9.50	13–4–1, 14–3–1, 10–7–1, 11–6–1 12–5–1	12½–4–½, 13½–3–½, 12–4½–½ 11–3½–½, 9½–7–½, 10½–6–½ 9–7½–½, 10–6½–½
9.00	14–4–1, 13–5–1, 12–6–1, 11–7–1	10–7½–½, 9½–8–½, 13½–4–½ 12½–5–½, 11½–6–½

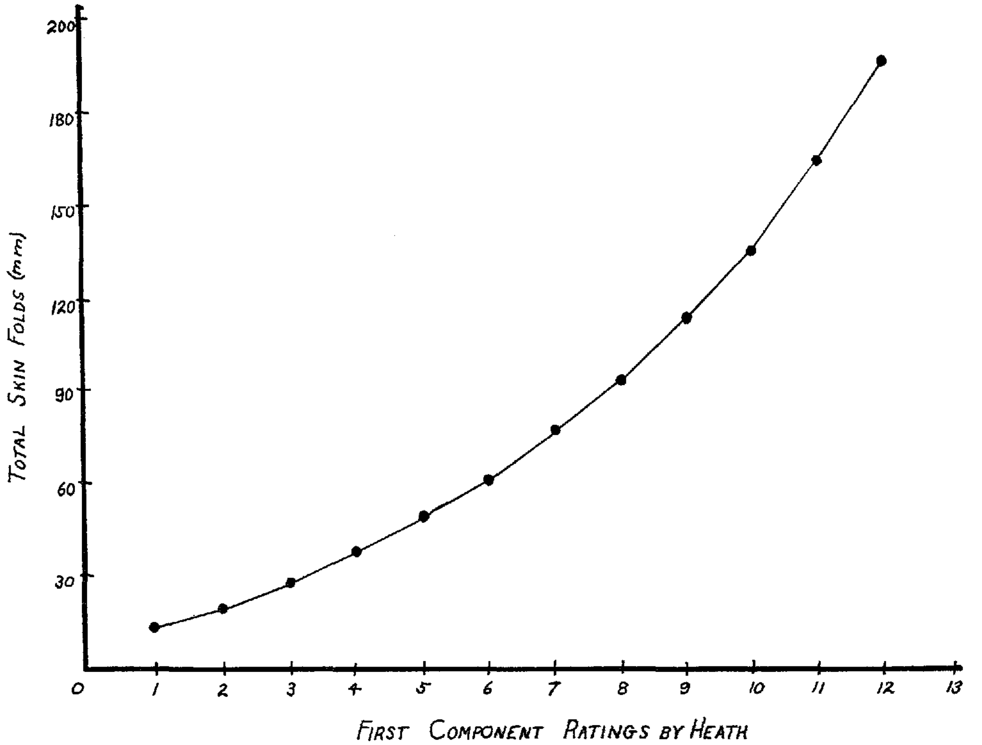

Fig. 3 Mid-points of the total skinfold values for each first component rating unit on the F-scale.

height/$\sqrt[3]{\text{weight}}$ ratios and third component ratings higher than *seven*. Table 2 was constructed so that the intervals for height/$\sqrt[3]{\text{weight}}$ ratios from 12.00 downward increased in a somewhat geometric progression. For each *one* rating change the intervals increase from 0.20 through 0.30, 0.40, to 0.50.

Validation of the anthropometric scale (F-scale) for the first component. Heath rerated 414 subjects (series nos. 1, 2, 3, 4) using the Heath method ('63) together with the readjusted height/$\sqrt[3]{\text{weight}}$ table (table 2), and with knowledge of total skinfolds. Carter independently established the first component ratings from the F-scale. The mean difference between the Heath rating and the F-scale rating, the reliability coefficient (r_{xy}), the percentage agreement *plus or minus one-half*, and the component range of Heath's ratings are presented for each series and for the mean of the series in table 3. The data indicate that the mean differences are small, the reliability and percentage agreement are high, and that the F-scale is an excellent tool for estimating the Heath rating for first component values ranging from *one* to *seven and one-half*. These values for component estimation are better than those reported in the literature as reviewed by Heath and Carter ('66).

Comment. Data on the obese females (series no. 5) provide our only information about the F-scale and Heath ratings above *seven and one-half*. As seen from table 3 the correspondence between the ratings is not good. Considering the need for estimating total skinfolds for this series, the unknown reliability of the skinfolds, the lack of muscle and bone measurements to estimate the second component, and the increasing variability of skinfolds at higher values, it is not surprising that the agreement with the Heath rating is poorer than at lower levels on the first component scale. The percentage agreement *plus or minus one* is 70%, and

TABLE 3

Comparisons of the criterion rating and scale rating for first and third somatotype components

Series	First component					Third component				
	N	Diff. Heath-F-scale	r_{xy}	% ± ½ unit	Range	N [1]	Diff. Heath-L-scale	r_{xy}	% ± ½ unit	Range
Athletes Males 17–37 years	162	−0.04	0.94	100	1 –4½	155	−0.27	0.95	87.8	½–6
N.Z.P.E. Males and females 18–52 years	131	0.00	0.97	97.7	1½–5½	128	−0.15	0.91	95.3	1 –5
U. S. College Males 17–28 years	102	−0.09	0.97	96.1	1 –7½	100	+0.11	0.93	90.0	1 –6
San Diego State Males 28–59 years	19	−0.19	0.96	84.2	1½–6	14	+0.35	0.94	85.6	1 –4
Mean of above series 17–59 years	414	−0.04	0.98	97.6	1 –7½	397	−0.22	0.98	90.7	½–6
TOPS Females 17–69 years	102	+0.36	0.68	48.0	5½–12	—	—	—	—	—
Manus Females 18–70+ years	42	+0.21	0.90	95.2	1 –4½	26	−0.12	0.64	85.0	1–3½

[1] Subjects with height/$\sqrt[3]{\text{weight}}$ ratios of 12.00 or more.

improves to 84% and 94% for *plus or minus one and one-half and two* respectively. Nevertheless, Heath found the skinfolds extremely valuable in assigning her rating. It would appear that greater reliance must be placed on the photoscopic rating at ratings of *eight* to *twelve* in the first component.

With reference to the Manus females (series no. 6), it is interesting to observe that, although 48% of the group were pregnant, their total skinfolds (mean = 21.6 mm) were very low for women, and that the reliability (r = 0.90) and the percentage agreement *plus or minus one-half* (95.2%) were high. This suggests that even under conditions of pregnancy the F-scale is still a useful indicator of endomorphy.

Since the use of the three skinfolds had been well established by Parnell ('54, '58), and many studies have used these measurements there seemed to be no good reason for changing the procedure. A question does arise, however, as to the use of the F-scale values for the aged, very small and very tall persons. Based on his studies and those of others, Brozek ('65, p. 6) concluded that skinfold compressibility decreases with age. In tall subjects (74 inches or more) one obtains proportionally larger skinfolds simply because the subject is large (Mayer, '59). Present data does not permit the F-scale to be used with small children but work is under way to develop scales for these groups. In this connection, consideration of Parnell's ('65) "total lean weight" with height corrections seems to be appropriate. In practice, we find the F-scale satisfactory for most heights from 60 inches and more. The limitations of very high skinfolds, compressibility of skinfolds, and size of subjects can be allowed for in the photoscopic rating.

Conclusion. An objective and valid scale which meets acceptable criteria has been developed for estimating Heath's first component rating.

The Second component

In a previous article, Heath and Carter ('66) examined the relationships between Heath's ratings and Parnell's ratings based on the M.4 deviation chart. The authors found poorer relationships on the second than on the first and third components, and they also noted that with older subjects the differences would likely be greater as Parnell's scales are age corrected. Since there were different patterns between the males and females on the second component and since the initial M.4 mesomorphy estimate is corrected for neither age, sex, nor fat, the addition of older subjects and a comparison of initial and final M.4 ratings with Heath ratings was suggested.

Initial and final M.4 data and Heath ratings were available on series nos. 2 and 4. Comparisons were made among three groups, N.Z. males, N.Z. females, and S.D.S. males. In five of the six comparisons the mean Heath rating was higher by *0.10 to 0.54;* percentage ratings *plus or minus one-half* ranged from 58–89%; the correlations ranged from r = 0.69 to r = 0.92; the percentage of high over low ratings ranged from 9–76%. Furthermore, Heath's ratings on the second component were approximately one unit higher than the M.4 rating in series no. 3. An individual analysis of selected photographs in each series indicated that the correction for high total skinfolds had forced ambiguously low second component ratings for many of these physiques.

Since the above observations showed that there were considerable discrepancies, a solution was attempted by readjusting the mesomorphy scale and changing the method of skinfold correction. We accept Parnell's general principle that given amounts of mesomorphy will be proportional to height, since somatotype is a measure of shape, not size — the taller the person the larger the musculoskeletal dimensions must be to maintain the same level of the second component. Although certain limitations have been cited, the anthropometric measures (humerus and femur biepicondylar diameters, flexed arm and calf girths) and scale adopted seem to be the best simple indicator of mesomorphy which we have (apart from the photograph). Keeping the basic structure of the M.4 chart for the second component intact, the following modifications were made.

The first modification was the moving of the height values one column to the left, thus effecting a *one-half* increase in the second component. The second modification was a direct skinfold correction to the limb circumferences. The t skinfold, but not the c skinfold, has been included in the M.4 measurements in the past. In our modificatoin a medial c skinfold, as suggested by Brozek ('60) is used for the correction of c girth. The simplest and most practical correction appears to be that of subtracting the skinfold value from the related limb girth *before* circling the appropriate value in the muscularity table (see center of figure 2). Although this is not claimed to be a "perfect" correction it is at least in the right direction and is applied only to the measurements which encompass skinfolds. This procedure also eliminates the age correction incorporated in Parnell's M.4 chart.

Validation of the anthropometric scale (M-scale) for the second component. Although the adjusted scale (M-scale) for the second component was available, individual validation against the Heath scale was limited by the absence of c skinfolds on the rated series. However, with adequate estimates for c skinfolds available from other samples the M-scale was applied to the means for series number 2 (male and female), series number 3, and on an individual basis to series number 4. Estimates for the c skinfolds for the females were taken from measurements on series number 7b, while those for the males were taken from measurements on series number 7c. As the means for the sum of three skinfolds of the subjects in series numbers 7b and 7c differed slightly from the means of series numbers 2 and 3, a percentage correction was applied to the mean c skinfold before calculating the second component.

In each of four comparisons, between the Heath rating and the M.4 rating and the Heath rating and the M-scale, the mean differences were reduced considerably. The Heath ratings were still slightly high in three of the comparisons — *0.11* for the N.Z. females, *0.16* for the N.Z. males, and 0.52 for series number 3. However, for series number 4 the mean difference was reduced from 0.35 to *zero,* with an r = 0.94, and 90% agreement within *one-half*. The Heath ratings on the second component ranged from *two* to *seven*.

Comment. When Heath and Carter ('66) used the Heath method for rating the second component, they reported better agreements than different raters using other methods. The difficulty then seems to stem from the anthropometric measures and the scales of their values. Another limitation in the M-scale is that, since fat is not distributed evenly around a limb, the double skinfold is at best an estimated correction. The alternatives of multiple skinfolds or cross-sectional analysis appear to be impractical for the limited gains possible. Empirically, the present M-scale appears to be more satisfactory for obtaining a Heath rating than the M.4 chart.

Conclusions. 1. The Parnell M.4 assessment of the second component is not a satisfactory estimate of the Heath rating.

2. The present M-scale is the preferred method for estimating the Heath rating for the second component in group studies, until the method can be further refined.

3. More reliance on the photograph and height/$\sqrt[3]{\text{weight}}$ ratio table is indicated for the second component rating than for the other two components over the same range.

The Third component

Heath's revised distribution of somatotypes for height/$\sqrt[3]{\text{weight}}$ ratios (table 2) shows two important features. To begin with, for the ratio 12.00 and above, the third component values appear to rise with the ratio in a linear fashion with no more than two rating values appearing at each ratio. Secondly, for height/$\sqrt[3]{\text{weight}}$ ratios below 12.00 there seems to be an even chance of the third component value being either *one-half* or *one*. Hence it can be seen that table 2 alone cannot be used to give the third component rating.

Since the distribution of somatotypes in table 2 represent a well established empirical population, the use of a regression equation to predict the third component value from the height/$\sqrt[3]{\text{weight}}$ ratio suggested itself. Accordingly, the third component values (Y) associated with given height/$\sqrt[3]{\text{weight}}$ ratios from 12.00 to 15.00 were plotted (fig. 4). For the 121 somatotypes the correlation was r = 0.97, and the regression equation for predicting Y from X is:

$$Y = 2.42\,X - 28.58$$

The majority of the somatotypes are within a half unit of the regression line and all are within the one unit boundaries. Using the above equation a scale (L-scale) was constructed for estimating the Heath rating (see bottom of figure 2).

Validation of the anthropometric scale (L-scale) for the third component. Ratings made by Heath, prior to the development of the L-scale, for the 397 subjects in series numbers 1, 2, 3, and 4, whose height/$\sqrt[3]{\text{weight}}$ ratios were 12.00 or more were used in the validation. Carter independently determined the third component ratings from the L-scale. The mean difference between the Heath rating and the L-scale rating, the reliability coefficient (r_{xy}), the percentage agreement *plus or minus one-half*, and the component range of Heath's ratings are presented for each series and for the mean of the series in table 3. Although the mean difference of − 0.22 shows that Heath rated slightly lower than the L-scale, the reliability (r = 0.98) and percentage agreement (91%) are high for the range of *one-half* to *six* on the third component.

Comment. The lower Heath rating of approximately *one-fifth* on the third component is attributed to the ratings on the series of athletes as the mean difference before adding this series was *zero*. It appeared that an unconscious rater bias favoring the lower of the possible ratings in table 2 was operating at the time of rating.

Although there are no subjects with ratings of *seven* or above in the third component in our present series, observation of other data indicates that the L-scale is an adequate estimator of the Heath rating at these high levels. When compared to the L-scale, the height/$\sqrt[3]{\text{weight}}$ ratio points established by Roberts and Bainbridge ('63) for somatotypes 1–2–8 (14.70), 1–1–8 (15.00), and 1–1–9 (15.20) are slightly low.

Since no further data to improve the prediction is available from table 2 or

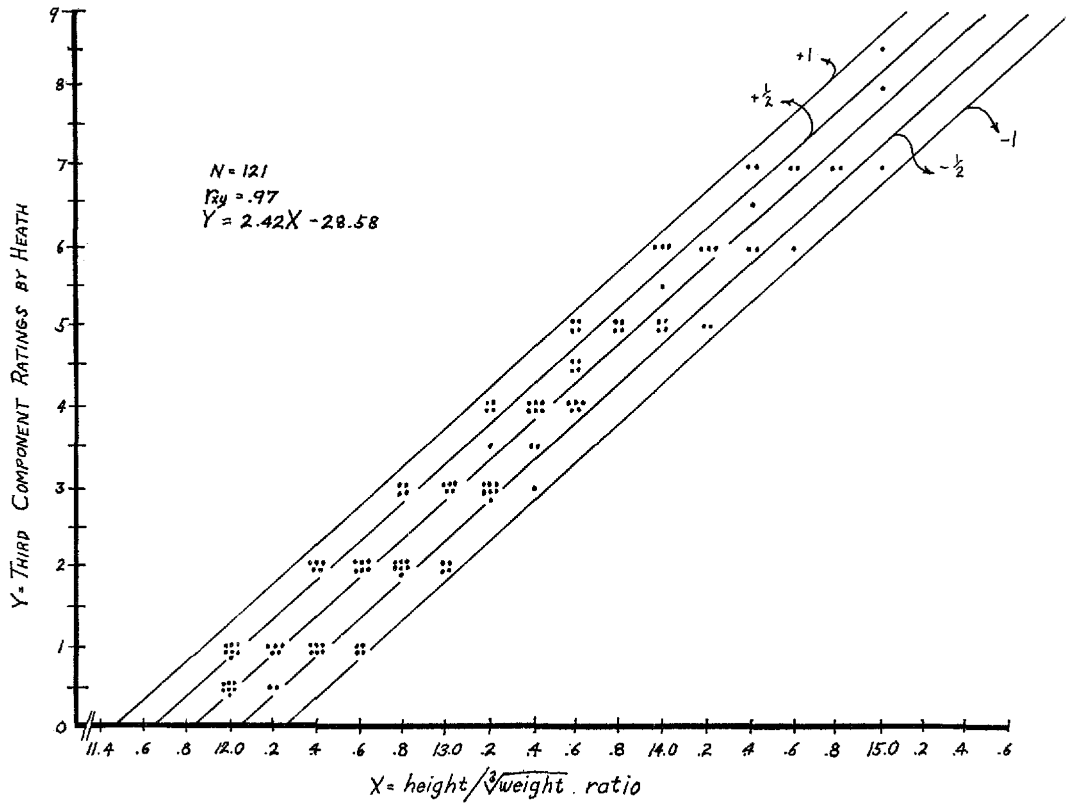

Fig. 4 Height/∛weight ratios versus third component ratings by Heath. The half unit and one unit boundaries from the regression line are shown.

the L-scale, those subjects with height/∛weight ratios below 12.00 are rated *one-half*. When the somatotype photograph is available the following rule should be applied:

> If the L-scale rating is *one-half*, but the subject shows slight tendencies towards linearity or elongation of the limbs or their segments, a rating of *one* should be assigned.

The data on the 26 Manus women (series no. 6) who had height/∛weight ratios of 12.00 or greater is included to illustrate a dilemma in rating the third component. Fourteen of the 26 (54%) were in varying stages of pregnancy. Since all had low skinfold totals the only evidence of excess weight was the localized abdominal protuberance. This leads to a conflict between the photoscopic impression and the height/∛weight ratio which must be resolved by the rater, and appears to account for the lower reliability and percentage agreement than in the other samples. No data is presented on the obese females (series no. 5) as 90% of the subjects had height/∛weight ratios of 12.00 or less.

Conclusions. 1. An objective and valid scale which meets acceptable criteria has been developed for estimating Heath's third component rating.

2. Better differentiation between a *one-half* and *one* rating can be obtained with the aid of the photograph.

The foregoing material has described the development of anthropometric scales for estimating the Heath rating. The scales are considered highly satisfactory for the first and third components, and satisfactory for the second component. The only exception appears to be that the scales are less reliable for subjects very high in the first component (*8–12*) and very low in the third component.

The following material is a description of the currently used Heath-Carter somatotype rating method, giving definitions, data required, and the rating procedures.

THE HEATH-CARTER SOMATOTYPE RATING METHOD

Definitions

1. A *somatotype* is a description of present morphological conformation. It is expressed in a three-numeral rating, consisting of three sequential numerals, always recorded in the same order. Each numeral represents evaluation of one of the three primary components of physique which describe individual variations in human morphology and composition.

2. *First component* (or endomorphy) refers to relative *fatness* in individual physiques; it also refers to relative *leanness.* That is, first component ratings are evaluations of degrees of fatness which lie on a continuum from the lowest recorded values to the highest recorded values.

3. *Second component* (or mesomorphy) refers to relative musculoskeletal development. Second component ratings are evaluations of musculoskeletal development which lie on a continuum from lowest to highest degrees recorded. The second component can be thought of as Lean Body Mass — an *in vivo* entity consisting of the musculoskeletal system, the soft organs, and total body fluids, or the whole body less nonessential fat (Behnke, '53).

4. *Third component* (or ectomorphy) refers to relative linearity of individual physiques. Third component ratings are based largely, but not entirely, on height/$\sqrt[3]{\text{weight}}$ ratios. Height/$\sqrt[3]{\text{weight}}$ ratios and third component ratings are closely related, so that at the low ends of their distributions both connote relative shortness of the several body segments, and the high ends connote elongation or linearity of the several body segments. Ratings evaluate the form and degree of longitudinal distribution of the first and second components.

Our definitions and concepts of the three somatotype components are derived in part from interpretations of studies of body composition. These include estimates of total body fat, total body water, and lean body weight (Behnke, '53, '59, '61, '63; Keys and Brozek, '53).

We emphasize that extremes in each component are found at both ends of continua. That is, low first component ratings signify physiques with little nonessential fat, while high ratings signify high degrees of nonessential fat. Low second component ratings signify light skeletal frames and little muscle relief, while high ratings signify marked musculoskeletal development, as in many athletes. Low third component ratings signify short extremities and low height/$\sqrt[3]{\text{weight}}$ ratios, while high ratings signify linearity of body segments and of the body as a whole, together with high height/$\sqrt[3]{\text{weight}}$ ratios. Extremes at both ends of all three somatotype component ranges connote rarity of occurrence. In the majority of cases ratings of all three components tend to be nearer to the midrange than at the extremes.

The rating scales

Ratings of each component theoretically begin at *zero* and have no arbitrary end point. In practice, no ratings less than *one-half* are given. *One-half* intervals are rated when appropriate in reconciling of inspectional criteria, anthropometric data, and height/$\sqrt[3]{\text{weight}}$ ratios. The same rating scales, height/$\sqrt[3]{\text{weight}}$ ratio criteria, scale of skinfold values, and scale of values for bone diameters and muscle girths are applied, with limited reservations only, to both sexes at all ages.

The data

1. Standard 5 × 7 in somatotype photograph (Sheldon, '54, Appendix pp. 345–349; Tanner, '49; Dupertius, '63).

2. Measurements: (see Parnell, '58)

   Age — years and months
   Height — in millimeters, or in inches and tenths
   Weight — in kilograms and tenths, or in pounds and half-pounds
   Skinfolds — triceps (t), subscapular (ss), suprailiac (si), calf (c) (measured on the right side, preferably with Harpenden caliper) in millimeters and tenths
   Bone diameters — humerus and femur, in millimeters
   Muscle girths — flexed arm, c, in millimeters

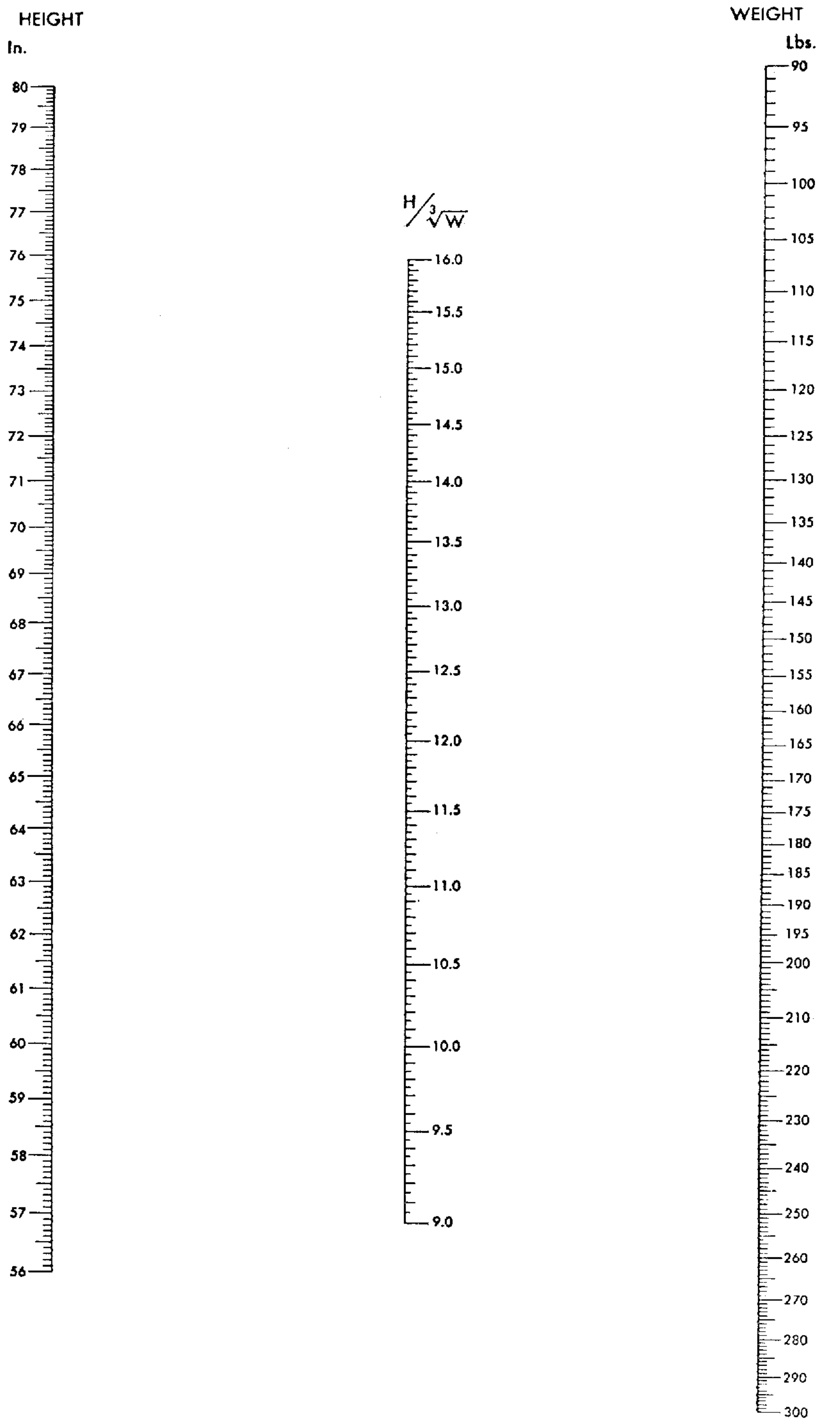

Fig. 5 Nomograph for determining height over cube root of weight when height is known in inches and weight in pounds.

Procedures for obtaining somatotype ratings

Essentially there are three ways of obtaining the somatotype rating. First, one can obtain an anthropometric somatotype rating, without having a somatotype photograph, when all of the recommended measurements have been taken. Second, it is possible for experienced somatotypers to make reliable photoscopic or inspectional ratings, when age, height, weight, and a standard somatotype photograph are available. The third method is the Heath-Carter somatotype rating which combines the previous two procedures.

The anthropometric somatotype (fig. 2). Record the subject information and the measurements in the spaces provided on the somatotype rating form.[2] To obtain the first component rating, sum the three skinfolds (t, ss, si), circle the closest value in the F-scale, and then circle the rating value for that column. To obtain the second component rating, mark the point of the subject's height on the height scale. For each bone diameter circle the figure in the proper row which is nearest the exact measurement. Subtract the t skinfold from the biceps girth, and the c skinfold from the c girth, before circling the figure in the proper row which is nearest the measurement. Dealing only with columns, mark the point that is the average of the circled figures for the diameters and girths only. Count the number of columns (and fractions) by which this average deviates right or left from the marked height, then move this number of columns right or left from the four in the second component rating and circle the closest rating value. The third component rating is obtained by finding the height/$\sqrt[3]{\text{weight}}$ from the nomograph (fig. 5) and recording it, circling the closest value in the L-scale, and circling the rating value for that column. Finally, the values for each component rating scale are recorded after "Anthropometric Somatotype" at the bottom of the form (fig. 2). An example using the above procedure is shown on the rating form.

The photoscopic somatotype. As mentioned above, long training and experience are required for obtaining reliable somatotype ratings when the data do not include the recommended anthropometric measurements. Inexperienced investigators find that the lack of a handbook of somatotype method makes accurate rating difficult. The Heath ('63) method depends primarily upon reference to table 2, the distribution of somatotypes and height/$\sqrt[3]{\text{weight}}$ ratios, and upon wide experience with recognizing the approximate rating values appropriate for each component. The final rating is given after reconciling height/$\sqrt[3]{\text{weight}}$ criteria and inspectional criteria. When the subjects are adult males it is useful to compare photographs with apparent prototypes at about age 18 as shown in ATLAS OF MEN (Sheldon, '54).

The Heath-Carter somatotype. In order to give a Heath-Carter somatotype rating the following are needed:

1. The somatotype photograph.
2. The Heath-Carter Somatotype Rating Form (fig. 2), upon which the data for the subject have been recorded.
3. Table 2, the distribution of height/$\sqrt[3]{\text{weight}}$ ratios and somatotype ratings.

In order to arrive at a final somatotype rating one must keep in mind that the somatotype photograph is a record of all the morphological characteristics which have been sampled by the anthropometric measurements. The objective is to reconcile the criteria of the height/$\sqrt[3]{\text{weight}}$ ratio, the criteria of photographic inspection, and the estimated anthropometric somatotype. The number of steps and the length of time required for obtaining the objective vary from subject to subject and from rater to rater.

When one somatotype component is clearly dominant, the table of somatotypes and height/$\sqrt[3]{\text{weight}}$ ratios alone narrows the possible choice of ratings. Height/$\sqrt[3]{\text{weight}}$ ratios identify extremes in the first and third components. It is therefore clear that the greatest difficulties are encountered in arriving at final ratings of the second component for midrange somatotypes, whose height/$\sqrt[3]{\text{weight}}$ ratios are also midrange. In most cases it is best

[2] Printed copies of the somatotype rating form may be ordered from Dr. J. E. L. Carter, San Diego State, San Diego, California, 92115.

to compare inspectional impressions and first component estimates obtained from the F-scale, then do the same for the L-scale. Using table 2 and the reconciled ratings for the first and third components identify the physiques at (or close to) the subject's height/$\sqrt[3]{\text{weight}}$ ratio which have similar first and third component ratings. Check the inspectional impressions of the second component with the M-scale, and finally, reconcile the photoscopic impressions, the anthropometric somatotype, and table 2, then assign the final rating.

For many physiques there are no differences between the anthropometric somatotype and the final combined rating. When there are differences, these are most likely to be *one-half* differences, except for subjects high in endomorphy where the difference may sometimes be as large as *one*.

CONCLUSION

A new and improved somatotype method which is reproducible has been justified, validated, and described.

DISCUSSION

The preceding operational definitions and procedures have evolved over many years of experience with both anthropometric and photoscopic ratings. The system as it is now applied is useful and logical. Over the years it has become increasingly obvious to those attempting to use somatotyping as a sound tool of investigation that it is more important to record what the somatotype is at a given time than to predict what the subject will be or might be. We unequivocally state that the operational definition of somatotype as given above is a descriptive device for recording present and future status (i.e., change), providing that actual ratings are made *on the same scale* at different points in time.

In spite of Sheldon's ('40, '54) protestations to the contrary, his "morphogenotype" is neither dynamic nor useful in its present form. In his discussion of the "morphogenotype" and "morphophenotype" the impression Sheldon gives is that somatotype implies predictability and that is *"good,"* and that phenotype does not imply predictability and that is *"bad."* Although prediction of data on a parameter at a different point in time is of value, the preferred method in most sciences is to measure exactly what the data are at that time. For example, although the genetic basis for stature is recognized and prediction of adult stature from certain ages is reasonably accurate, one still *measures* stature periodically against the *same scale* and certainly does not use the age-normed scales as the measuring scale. Furthermore, as the word "phenotype" is not specific to somatotyping but has general use in biology, we suggest that its use as a noun be discontinued. Sheldon's age-weight corrected scales were designed primarily to support the premise that the somatotype is permanent. The validity of these age-weight corrected tables is questionable because they were constructed by interpolation and extrapolation of weight histories which in themselves are often unreliable (see Damon, '65). The data also were drawn almost entirely from cross-sectional studies, which with secular changes in height and weight are by now far outdated. Such scales as Sheldon's are to be regarded purely as percentile or standard scales which slide to match each other at different age levels and are not suitable for observing change.

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