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The Concept and Method of Anthropometric Somatotype, with an Example from the Oraon Tea Garden Labourers of Jalpaiguri District, West Bengal

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Abstract : The concept, method and usefulness of somatotype study are presented, with a brief sketch on its historical development. The anthropometric somatotype method of Heath and Carter has been described in details. The aim of the study, in addition to the above mentioned points, is to find out whether any relationship exists between somatotype and actual work performance/productivity. An example has been cited from a study of the Oraon tea garden labourers of Jalpaiguri district, West Bengal. The result does not show any statistically significant difference between high and low pluckers of either sex in respect of the three somatotype components, but the preponderence of high ectomorphic scores in all the plucker categories, especially the high pluckers, suggested that ectomorphs are physically more active.

'Somatotype' denotes body shape and physique type in humans, and the corresponding method describes the variation between and within human groups numerically. These numerals express information on individual physical constitution in an easily comprehensible form compared to an array of anthropometric measurements presented as such.

There have been numerous attempts to classify the varieties of human physique. One can make a number of anthropometric measurements on an individual and compare each of them with a range of values collected from a 'standard' group of the same age and sex, but this approach does not readily help visualisation of the body shape (Harrison *et al.* 1977). A number of techniques have emerged over time to describe the human physical form.

Without going into the early efforts made by Viola and Kretschmer (see Harrison *et al.* 1977 for review), we shall go directly to Sheldon's system of visual classification of somatotypes in which human body build was classified in terms of three extreme types on the basis of nude standardized photographs showing front, side and rear views : endomorphy (round, fat type), mesomorphy (muscular type) and ectomorphy (slim, linear type). Sheldon *et al.* (1940) devised a 7-point (1-7) rating scale with equal sized intervals between the numerals for each type, ignoring the attribute of largeness or general body size. The set of three numerals in series constituted a person's somatotype. Hence, the extreme endomorph has the somatotype 7-1-1, extreme mesomorph 1-7-1, and extreme ectomorph 1-1-7, but in practice, extreme types are rare or non existent, and an individual of normal build has an evenly balanced somatotype approaching 4-4-4. However, this subjective assessment of somatotype has many criticisms, eg. the inadequacy of third component (ectomorphy) for describing the extremely tall and lanky Nilotes (Roberts and Bainbridge 1963).

Several attempts were made to modify Sheldon's method by replacing anthroposcopic observation with anthropometric measurements and applying statistical tools (Eysenck 1945, Hammond 1953, Tanner 1951, Hooton 1959, Parnell 1958), but they all soon lost their usefulness. Several other techniques evolved, involving the analysis of tissue components (Tanner *et al.* 1959, Behnke 1961), consideration of disproportions or extreme values of somatic indices (Seltzer 1946), attempt at human engineering (Damon *et al.* 1962), and a complicated interdisciplinary method for determining body density and water content (Brozek 1966).

Considering all these methods, especially the modified technique of Sheldon, Heath (1963) suggested modification and adaptation of Parnell's (1958) somatotype methodology, and Heath and Carter (1969) extended and readjusted the universal rating scales and criteria applicable to both sexes at all ages and constructed tables to enable investigators to obtain reliable anthropometric somatotype ratings, which are presently used widely.

Anthropometric somatotype studies of Heath and Carter have been used for various purposes, including demonstration of similarities/differences between and within different groups (Prakash and Malik 1989), during the last two decades. The most extensive use of somatotyping has been made in evaluating the relationship between physique and physical performance of athletes at various competitive levels in a variety of sports (Carter 1970, Parizkova 1970, 1972, de Garay *et al.* 1974, Ross *et al.* 1977, Withers *et al.* 1987). Somatotype is influenced by a number of factors, including age (Zuk 1958, Heath and Carter 1971, Walker 1978), sex (Tanner 1962, Parizkova and Carter 1976, Carter and Parizkova 1978), smoking habit (Prakash and Malik 1988), nutrition (Malik *et al.* 1986a) and other environmental factors (Malik *et al.* 1986b, Singh *et al.* 1986). The available information on the relationships between physique and different physiological functions is still inadequate, although it has been used in studying growth (Zuk 1958, Walker 1974, Singh 1976), in diagnosing diseases (Spain *et al.* 1955) and assessing the effects of environment, behaviour and physical performance on it (Baily *et al.* 1982). Studies on the relationships between work performance/productivity in different working situation and somatotype are also lacking.

In view of this, the present study aims to (1) report the somatotype of the Oraon tea garden labourers of Birpara and Dalgaon tea gardens in West Bengal; and (2) evaluate whether high or low work performance is related to any specific kind of somatotype (if so, which component out of the three is more closely related to performance in tea leaf plucking).

METHODOLOGY

Data were collected as a part of an ongoing project on 161 adult (20 years and above) tea garden labourers (pluckers, who pluck green leaves from the tea bush). Of these, 88 were females and 83 males. They belonged to the Oraon tribe from the tea gardens of Birpara and Dalgaon in the Jalpaiguri district of northern West Bengal.

The Oraons are a Dravidian speaking population with its major concentration in the Chotanagpur plateau in Bihar. They are believed to have migrated to northern West Bengal about the end of the last century (Choudhury 1978). Anthropometric measurements were made using standard instruments and techniques (Weiner and Lourie 1981).

The following measurements were taken from subjects wearing light apparel :

1. Stature (cm.)
2. Body weight (kg.)
3. Biepicondylar breadth of humerus (cm.)
4. Upper arm circumference (cm.)
5. Biepicondylar breadth of femur (cm.)
6. Calf circumference (cm.)
7. Skinfold thickness, triceps, left (mm.)
8. Skinfold thickness, subscapular, left (mm.)
9. Skinfold thickness, suprailiac, left (mm.)
10. Skinfold thickness, Calf, left (mm.)

According to the method of Heath and Carter (1967), the somatotype is expressed in a 3-numeral rating system consisting of 3-sequential numerals, always recorded in the same order. The first component, endomorphy, refers to the relative fatness and leanness in individul physique. The second component, mesomorphy, refers to the musculo-skeletal development per unit of height and can be treated as the relative lean body mass. The third component, ectomorphy, refers to the relative linearity of individuals and it is based on ponderal index.

Detailed methodology to determine the somatotype rating

Before obtaining the somatotype rating, appropriate data should be entered in the appropriate place at the left side of the rating form (Figure 1).

First component (Endomorphy) rating

1. Calculate the sum of three skinfolds (Triceps, subscapular and suprailiac) and record it at the right side of TOTAL SKINFOLDS = (Figure 1 shows the value 27.0).
2. Go to the numerical section (right side block) and choose the appropriate value which is very close to the value of total skinfolds. Then encircle that value (Figure 1, 27.0).
3. Look to the row of 'First Component' and observe carefully which value is directly under (vertically) the column you have already encircled. Again encircle that value (Figure 1, 3.0). Now, you have got the first component.

Second component (Mesomorphy) rating

1. Go directly to the numerical section (right side block) and consider only the horizontal row of height, mark the point of the subject's height by a downward arrow (↓) on the nearest value of height (regard the height row as a continuous scale. Figure 1, 154.9).
2. For each of the measurements of left side (Bone : humerus and femur) go directly to the the right side block, consider each horizontal row and encircle the value which is nearest to the value of the left side (Figure 1, 5.05 and 8.24, respectively).
3. Subtract the triceps skinfold thickness value from Muscle : Biceps (note that triceps skinfold thickness has been measured in mm. unit and Muscle : Biceps in cm. unit, so it would be best to divide skinfold thickness measurement by 10, then subtract the value from Muscle : Biceps). In case of calf, again subtract the calf skinfold thickness (keeping in mind the the transformation of the unit) (Figure 1, 20.0 and 28.0, respectively).
4. For each corrected value obtained from 3 (Muscle : Biceps/calf), go along the row on the right side block and encircle the value which is nearest to the value on the left side (Figure 1, 20.4 and 27.7, respectively).
5. Now, do not look at the numerical values. Consider only columns, ignore the height row and take the other four rows (Humerus, Femur, Biceps, Calf) of the right side block.
6. There will be four encircled figures in the four rows. Out of these four, take the left-most encircled column as '0' (Zero) or as the base point (Figure 1, 20.4 in the third row), then count the column deviations of the other three encircled figures along the row. Add the total deviation of the three encircled figures and divide the total by 4 (Figure 1, 4+9+5 =18 ; 18/4=4.25).

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ANTHROPOMETRIC SOMATOTYPE RATING FORM (following Heath-Carter)

ID.NO. ______ NAME Sukri Oraon AGE 21 SEX M (F)

OCCUPATION T. G. Labour ADDRESS Dalgaon T.E

PROJECT ______ MEASURED BY ______

Skinfolds (mm)

Triceps = 7.6
Subscapular = 12.0
Suprailiac = 7.4
TOTAL SKINFOLDS = 27.0
Calf =

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
ENDOMORPHY — First component	0.5	1.0	1.5	2.0	2.5	**3.0**	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0

Height (cm) = 154.2
Bone : Humerus (cm) = 5.0
Femur = 8.2
Muscle: Biceps (cm) = 21.0 *(triceps skinfold) 0.8
Calf = 28.5 *(calf skinfold) 0.5

Height	120.7	124.5	128.3	132.1	135.9	139.7	143.5	147.3	151.1	154.9	158.8	162.6	166.4	170.2	174.0	177.8	181.6	185.4	189.2	193.0	196.9	200.7	204.5	208.3
Humerus	4.47	4.61	4.76	4.91	**5.05**	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
Femur	6.37	6.58	6.79	7.00	7.21	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
Biceps	**20.4**	21.0	21.7	22.4	23.0	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
Calf	23.9	24.6	25.4	26.2	27.0	**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

MESOMORPHY — Second component	0.5	1.0	1.5	**2.0**	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5

Weight (kg) = 45.0
Ht./ $\sqrt[3]{\text{Weight}}$ = 43.29

Upper limit	39.65	40.74	41.43	42.13	42.82	**43.18**	43.84	44.84	45.53	46.23	46.92	47.58	48.25	48.94	49.63	50.33	50.99	51.68
Mid-point	and	40.20	41.09	41.79	42.48	43.14	43.48	44.50	45.19	45.89	46.32	47.24	47.94	48.60	49.29	49.99	50.68	51.34
Lower limit	below	39.66	40.75	41.44	42.14	42.83	43.49	44.19	44.85	45.54	46.24	46.93	47.59	48.26	48.95	49.64	50.34	51.00
ECTOMORPHY — Third component	0.5	1.0	1.5	2.0	2.5	**3.0**	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0

	First component	Second component	Third component	Co-ordinates X	Co-ordinates Y
Anthropometric Somatotype	3.0	2.0	3.0	0.0	-2.0

Signature of Rater ______

Figure 1

7. Take the number obtained by division described in point 6. Still consider the left-most encircled column (eg. 20.4 in the fourth row) as the base point and count the number (obtained by division) horizontally towards the right side column (count each column as 1). Mark a point (.) to the column position reached after counting (Figure 1, after 23.0) ; it may be a fraction between two consecutive columns. Then go vertically up along the column marked with a point to the height row and mark a point with a asterisk (*) on that row (Figure 1, between 135.9 and 139.7).
8. Consider the columns only, count horizontally the column deviation from asterisk (*) to mark of height (↓) or vice versa.
9. Remember the column deviation (done in 8), look to the row of 'Second component' and consider '4' as the base point. Then move towards left or right horizontally (depending upon the direction of the asterisk from the height marker). Now, count the number of column deviation from 4 and encircle the second component figure. Note : If the asterisk is to the right of height then count 4+ figures and if the asterisk is to the left then count 4— figures. Caution : In this row, the unit in consecutive columns has a half-unit increment (Figure 1, 2).

Third component (Ectomorphy) rating

1. Calculate the ratio height/$\sqrt[3]{\text{weight}}$ (Ponderal index, except that here multiplication by 100 is not done).
2. Look to the right side block and encircle the value very close to the ratio (Figure 1, 2nd row, 43.14).
3. Look to the row of 'Third component' and locate the value directly under (vertically) the column already encircled. Encircle the value (Figure 1, 3.0). Now, the Third component is obtained.

Use of Somatochart and putting the somatotype rating on somatochart

Somatochart is a schematic, triangular shaped, two-dimensional representation of the theoretical range of known somatotypes, first devised by Sheldon (1940). The distribution and concentration of somatotypes are plotted on somatocharts (Figure 2). Somatocharts are used to graphically represent the somatotype data, which also show the relative dominance and pattern of the components.

The somatochart is apportioned into different sectors by three axes which intersect at the centre of the 'triangle'. These sectors and the somatotypes in them are given names according to the relative rank or dominance of the components of the somatotype. Thus, somatochart is an useful framework for comparisons of data.

Any point on a graph is represented by two values known as coordinates. A graph is represented by two axes, viz. X and Y. In case of somatochart the axes has been extended to X X' and Y Y' and the intersection is at the centre of the triangle where the value of X and Y is Zero.

First of all, how to obtain the values of X and Y for each individual ? The procedure is as follows :

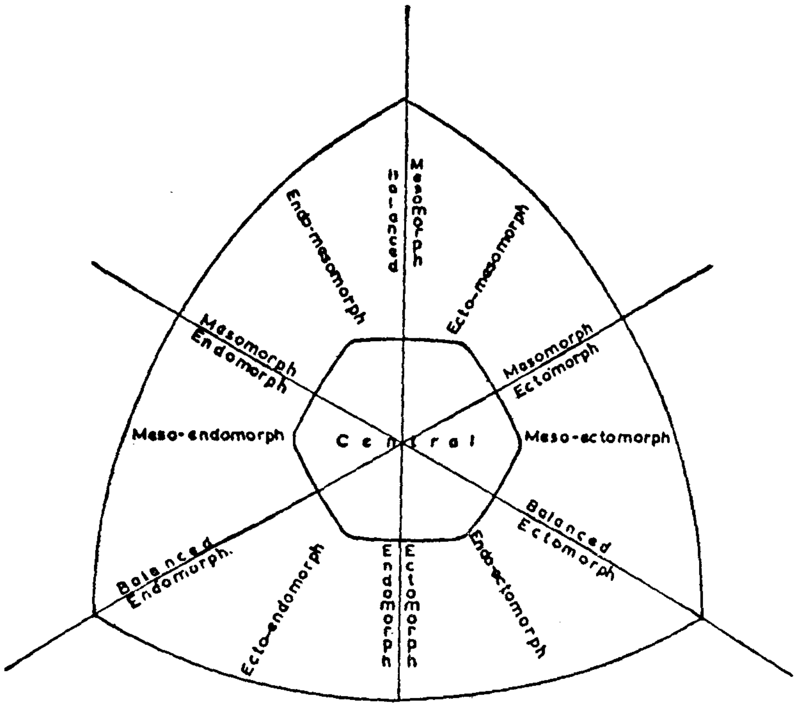


Figure 2.

X = Ectomorphy – Endomorphy

Y = (2 × Mesomorphy) – (Ectomorphy + Endomorphy)

(In case of X, the value of first component is subtracted from third component value. In case of Y, the value of second component is multiplied by two and the value of first plus third components is subtracted from it.)

Therefore, positive or negative values will arise and they will be plotted accordingly.

Take a somatochart and draw a straight vertical line from mesomorphic end to the bottom of the triangle through the centre (Y Y′) and then draw a horizontal line from Meso-endomorph region to Meso-ectomorph region through the centre, consider the horizontal line as X′ X then there will be four sectors (1) X Y (both positive values), (2) X′ Y (X – negative, Y – positive) , (3) X′ Y′ (both negative values), and (4) X Y′ (X – positive, Y – negative). A specimen somatochart has been given in Figure 3.

Classification of individuals in the study population into high and low pluckers

Classification of high and low pluckers was done in the following manner : In case of tea gardens of the Duars area, the garden authority considers plucking of 25 kg. of green leaves per day as the statutory 'task' for an individual plucker, male or female. For plucking over and above the 'task', extra remuneration is paid. It has been observed that almost everyone plucks more than 25 kg. during the peak plucking season. A frequency polygon was, therefore, drawn of the amount of green leaves plucked by each individual plucker, and it was

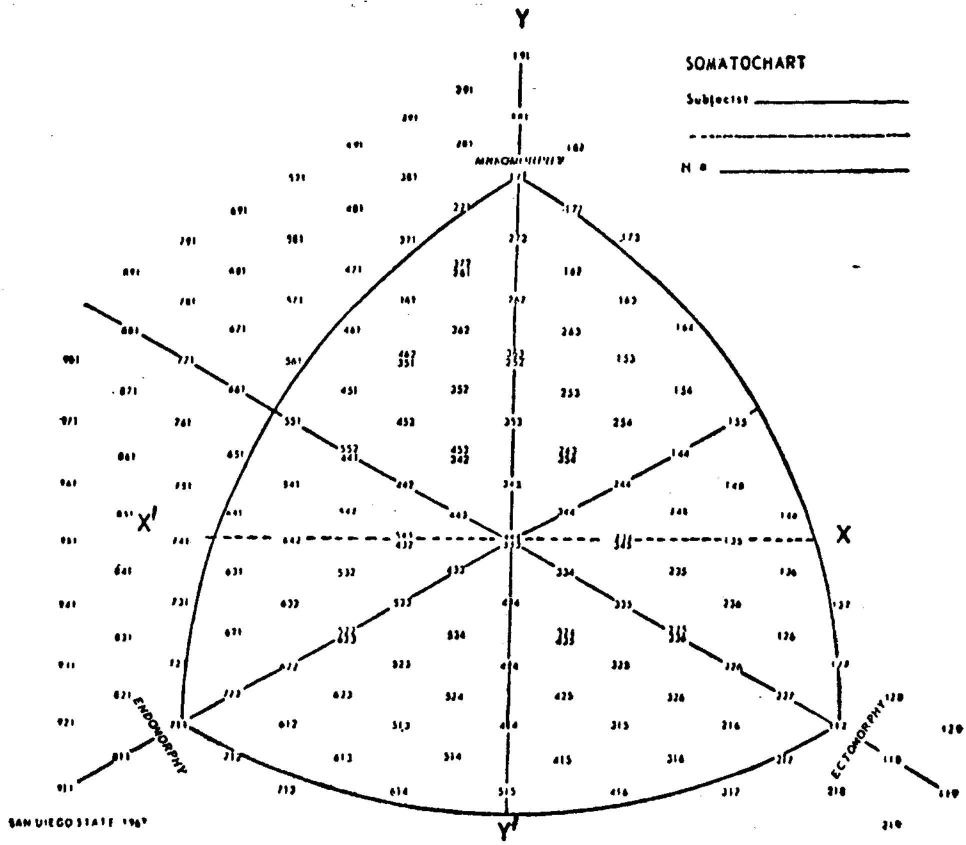


Figure 3.

found that an anti-mode existed around 35 kg., for both males and females. Therefore, 35 kg. was considered as the cut-off point for classifying low and high pluckers, for both sexes.

RESULTS AND DISCUSSION

The means and standard deviations of the somatotype scores, derived from anthropometric measurements, of the four plucker categories (high and low pluckers of both sexes) are presented in Table 1.

Among all the plucker categories, the third component, ie. ectomorphy, predominates followed by mesomorphy and endomorphy, respectively. Low plucker of both sexes have relatively higher values of endomorphy than high pluckers. The somatochart for males (Figure 4) do not show any striking difference, but in case of females, the high pluckers (Figure 5) tend to occupy the ectomorphic zone while low pluckers tend to have a diffused distribution relatively closer to centre.

The results of F-test between high and low pluckers (Table 2) show that there is significant difference between the two categories of male pluckers in respect of mesomorphic and ectomorphic scores, but the females show difference in respect of ectomorphic scores only.

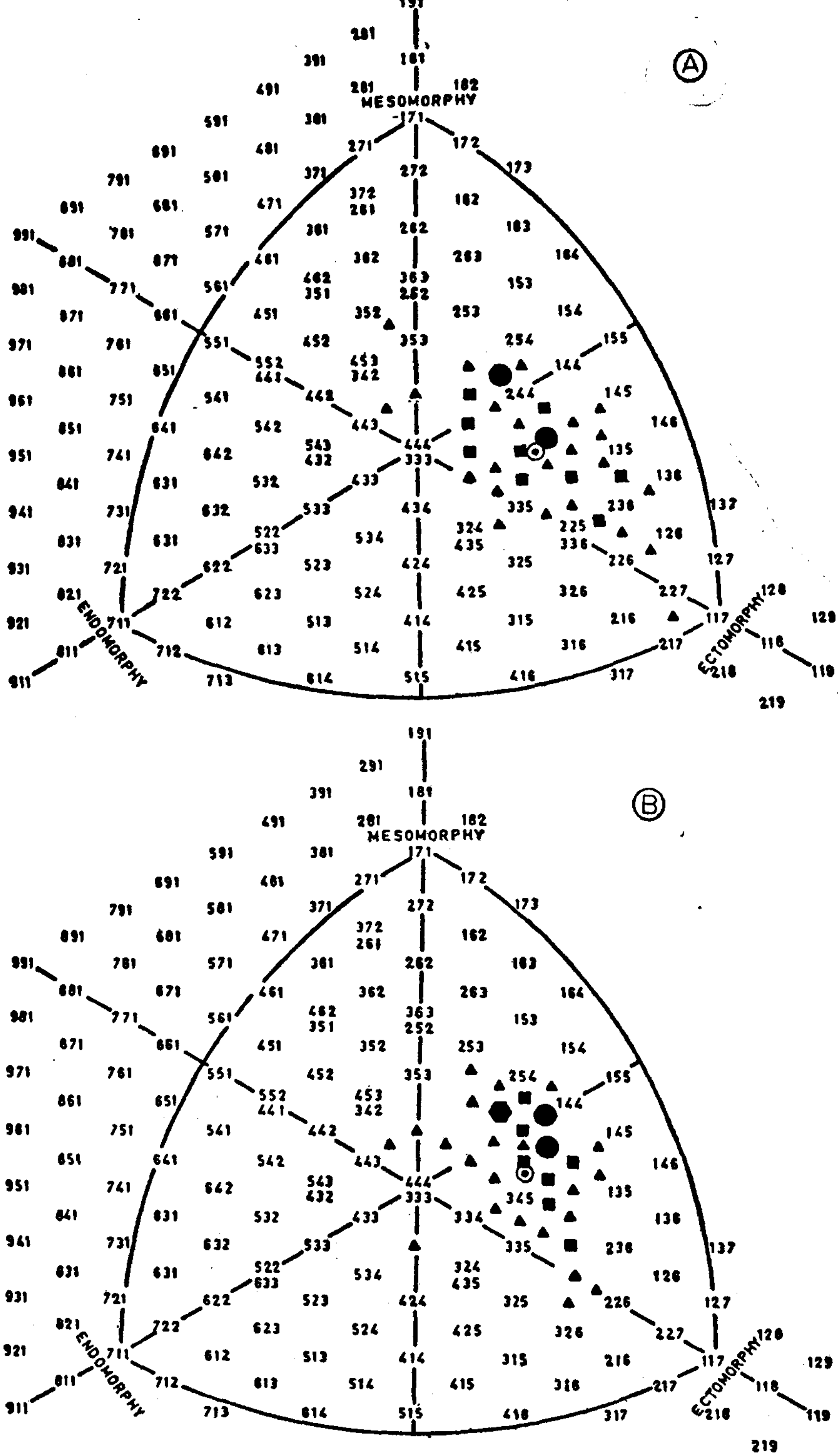
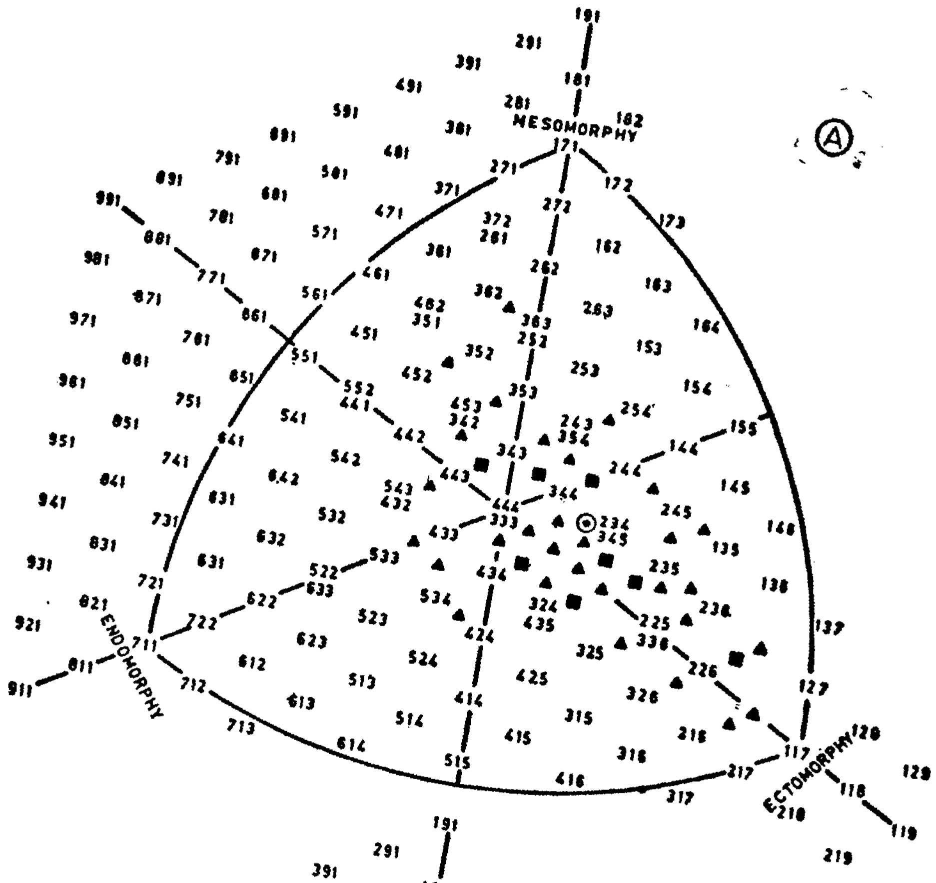


FIG.6 SOMATOCHART : MALE

Ⓐ LOW PLUCKER (N:47) Ⓑ HIGH PLUCKER (N:46)

● FOUR SUBJECTS
● THREE SUBJECTS
■ TWO SUBJECTS
▲ ONE SUBJECT



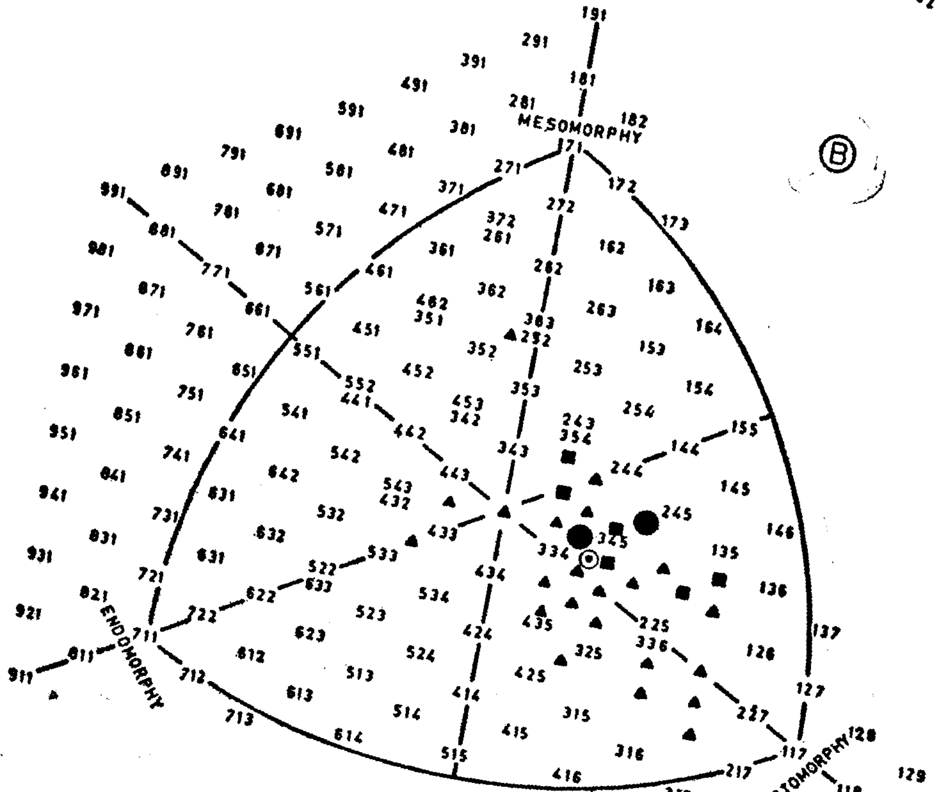


FIG. 5

SOMATOCHART : FEMALE
(A) LOW PLUCKER (N: 49) (B) HIGH PL

Table 1: *Somatotype scores, by pluckers category and sex*

Somatotype	Plucker category and sex	Male High plucker	Male Low plucker	Female High plucker	Female Low plucker
	Mean	1.46	1.63	1.79	1.89
Endomorphy	SD	0.45	0.54	0.78	0.96
	N	46	47	39	49
	Mean	3.0	2.76	2.24	2.44
Mesomorphy	SD	0.85	0.67	0.78	0.88
	N	46	47	39	49
	Mean	3.54	3.85	3.67	3.45
Ectomorphy	SD	0.68	1.03	0.88	1.13
	N	46	47	39	49

Table 2: *F-test between high and low pluckers by sex category*

Somatotype	Male	Female
Endomorphy	1.44	1.51
Mesomorphy	1.61*	1.27
Ectomorphy	2.29*	1.65*

* Significant at 5% level

In sum, somatotyping is an useful method of describing individual/population variation and may be used, particularly, for representing body size and shape variations. Although the present study of the tea garden labourers do not show any significant somatotypic difference between high and low plucker categories of either sex, the tendency of high ectomorphic scores and low endomorphic scores among all pluckers, particularly among high pluokers, clearly indicate that the total body fat is small (endomorphy) in all the plucker categories, which may be the effect of exercise (physical work. ie. tea leaf plucking, may be considered as a kind of exercise). On the other hand, the body weight per unit of stature (ectomorphy) is small (high ectomorphy) in this population, although musculo-skeletal development per unit of stature (mesomorphy) is comparable to other populations. Therefore, relatively low fat content and weight per unit of stature may help easy movement of limbs.

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