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CORRELATION AMONG PHYSICAL MEASURES APPLICABLE IN HUMAN ENGINEERING

BY

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ABSTRACT

By using the previously reported various kinds of measured values on human bodies from the view points of human engineering, which values had been obtained by measuring 41 items representing various parts of a body of Japanese young and middle aged men, the correlation coefficients between each of five basic measured values, i.e., those of body height, body weight, chest girth, sitting height, and buttock-leg length, and each of measured values of other 40 items were determined, and were viewed from various different angles. The main results are summarized as follows.

1) The correlation between each of measured values of body height, body weight, chest girth, sitting height, and buttock-leg length, and each of other measures were calculated and the significance of the correlation coefficients was studied.

2) The difference between these correlation coefficients was tested and these correlation coefficients were classified into those having higher correlation and lower correlation.

3) The results showed high correlation between measures in lengths and between measures in widths.

4) Head length, interpupil distance, first finger length, medical malleolus height, etc., did not show any significant correlation with each of body height, body weight, chest girth, sitting height, and buttock-leg height.

5) High correlation coefficients between body height and measures in length was observed, especially in the age group of thirties, but lower in forties.

6) A linear regression equation by which other measured values might be inferred from the values of body height, body weight, chest girth, sitting height, and buttock-leg length was determined and shown.

INTRODUCTION

Previously, new machinery or tool was designed solely in the interest of the machine or tool itself with little attention to the worker's fatigue resulting from the use of a machine or to easiness of the worker who operates or works with the machine. As a result, compatibility with physical characteristics of and behavior by the human body was often ignored, the

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machine ruling the worker to cause unnecessary fatigue and accidents.

Recently, with the development of the study of human engineering, these facts have come to draw attention of those concerned and many efforts have been made to create a comfortable yet safe environment for the worker by designing tools and machinery compatible with the human being from psychological and physiological standpoints.

The shortest way to this end is to obtain a proper knowledge of the shape, contour, and measurements of the body structure of a human being. Measurements of human body including height, weight, girth, and sitting height have thus far been made in various fields according to age and sex. However, due to the limit of time and economy, data on measurements of various detailed parts of the human body are available only on a small number of subjects. Moreover, morphological measurements require consideration of total body physiognomy, *i.e.*, skeletal and muscular contents both and their functions, instead of the previous concentration on hereditary and constitutional aspects leading to skeletal measurements alone. It is also extremely important to consider the working posture.

In the United States, Henry and Dreyfus[1] obtained in 1960 detailed statistical data on body measurements for both American males and females. Currently, a study is in progress in the U.S.A., on the measurement of various machinery and tools used in everyday life by humans, the buildings occupied by people, their transportation facilitates, and even their clothing for practical applications of such measurements.

However, studies in this field in Japan have been left behind at present, with the result that investigative material covering various detailed items of measurement is almost unavailable here, save in only a fragmental form. At present, Japan is utilizing the American data in an adapted form but this is clearly irrational in view of the marked difference in somatotype, physical structure, and function between the two nations.

To answer such a need the author has made measurements of body parts of a group consisting of more than 1,000 representative Japanese young and middle-aged men, which data have previously been reported[2-5].

Such measurements give valuable data in themselves. However, these crude data are not always directly applicable to specific machinery or situations, a specific period of time, or a specific human group. It will be more practicable to substitute it with a small number of selected items. Indeed, it cannot be said that the physical characters of the Japanese people remain unchanged but a fairly constant relationship between the measurements of different body parts can be expected to persist and some relationship may persist as absolute. The author, therefore, discussed in this report correlation coefficients among various items of measurement, classified the items into either markedly interdependent or independent categories, and

sought to develop a regression equation for items with a profound relationship to one another to avoid overlapping of measurement.

Investigation Method

1. Data

In 1963, a certain group of young and middle-aged men was first divided into age groups from which about 1,000 persons were extracted at

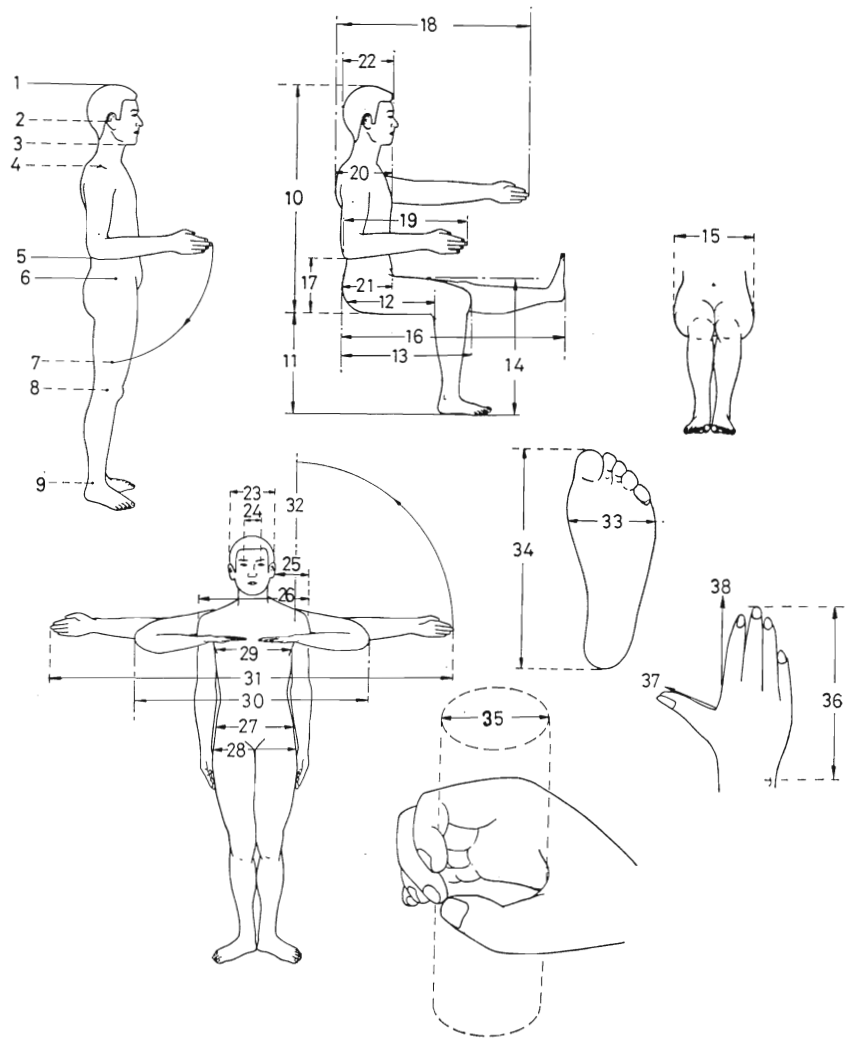

Fig. 1. Items of measurement
Number of items is the same as that in Table 1.

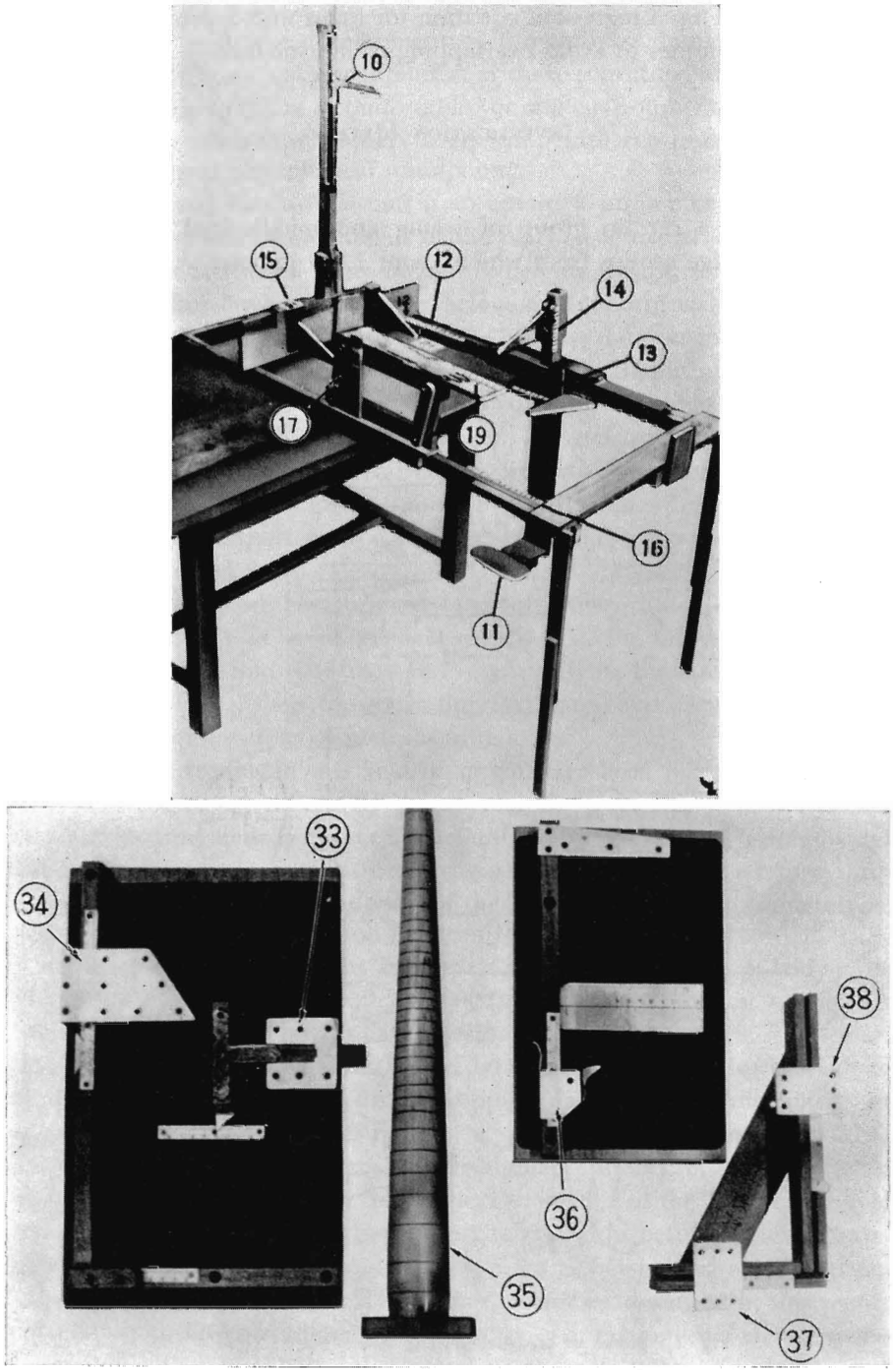

Fig. 2. Measuring apparatus of the Tokyo Medical and Dental University Type.

a ratio of 1/160 to use their measures as reference data. The ages and number of persons extracted are about 850 persons of an age between 20 and 29, about 120 persons of an age between 30 and 39, and about 110 persons of an age between 40 and 49.

Measurements were made on 41 items covering various parts of the body, as shown in Fig. 1, by means of Martin's anthropometer and a measuring apparatus of the Tokyo Medical and Dental University type (Fig. 2). Then, by a random sampling of the results of measurement thus obtained, 100 persons for each of the age groups of twenties, thirties, and forties were selected. The measures of these selected persons were analyzed in the following manner.

2. Analytical Method

The arithmetic mean (M), standard deviation (σ), coefficient of variation (V), and the like of each age group were first calculated (Table 1). Then, as typical of body measurements which are generally most available, five items such as body height, sitting height, and buttock-leg length representing measures in length, chest girth representing measures in girth, and body weight representing measures in weight were selected to determine the correlation coefficients of 40 items to these five items for each age group. In this instance, with respective measured values expressed by x and the number of persons measured by N, there were obtained the arithmatic mean, $\bar{x}=\sum x_i/N$, standard deviation,

$$\sigma=\sqrt{\frac{\sum(x_i-\bar{x})^2}{N}},$$

and coefficient of variation $V=\frac{\sigma}{M}\times 100\%$. Regarding body height, body weight, chest girth, and sitting height, the above data were compared by the *t*-test with the respective mean values ($\bar{y}$) of the corresponding age groups in the National Nutrition Survey in 1963 by the Ministry of Health and Welfare (by sampling method)[6], i.e.,

$$t=\frac{\bar{x}-\bar{y}}{\omega\sqrt{\frac{1}{n}+\frac{1}{m}}} \quad (d.f.=n+m-2)$$

where $\bar{x}$ is the sampling mean value of group x in which n is the number samples, $\bar{y}$ is a sampling mean value of group y in which m is the number of samples, and ω is the covariance.

The correlation coefficient (r) is determined from the following equation:

$$r=\frac{\sum(x-\bar{x})(y-\bar{y})}{\sqrt{\sum(x-\bar{x})^2\sum(y-\bar{y})^2}}$$

On the basis of the test on the significance of the correlation coefficients thus obtained and on the significant differences between the correlation coefficients, discussions were made of the presence and degrees of the correlation, and the correlation coefficients of each age groups were compared with each other and the changes were examined.

Finally, the regression coefficients (b) and the regression equations of each of measured items of body parts (y_1–y_{41}) with respect to each of body height (x_1), sitting height (x_2), buttock-leg length (x_3), chest girth (x_4), and body weight (x_5) were determined by the use of the least square principle. The above-mentioned calculations were conducted by using a computer program 101 of Olivetti.

Test on significance of correlation coefficient

The test was made by comparing the calculated values of t according to the following equation with Fisher's t-test

$$t=\frac{r\sqrt{N-2}}{\sqrt{1-r^2}}$$

Test on significant difference between two correlation coefficients (r_1, r_2).

When (t) was determined by the equation given below, according to differences which were obtained by using previously z-converted values[7] of (r_1) and (r_2), (t) showed a normal distribution. In this connection, the significant difference was determined at the level of significance of 5%, *i.e.*, the value exceeding t=1.96,

$$t=\frac{z^1-z^2}{\sqrt{\frac{1}{N_1-3}+\frac{1}{N_2-3}}}$$

Since it was very complicated to use the above equation in the test of significant differences between all of the correlation coefficients, a test graph[8] showing the significant difference was prepared with N_1=N_2=100 and the test was actually carried out using such a graph (Fig. 3).

Results

1. Correlation between body height and each of measures 40 other items (Table 2):

In this correlation, all of the measures respectively showed a positive correlatoin except the elbow height (5) (r=−0.01) in the age group of

Table 1. Mean (M), standard deviation (σ) and variation coefficient (V) of physical measures by age group

Age group (No. of subj.)	20～29 (N=850)			30～39 (N=120)			40～49 (N=100)		
	M	σ	V	M	σ	V	M	σ	V
1 Body height	166.2	4.3	2.6	164.5	5.4	3.3	162.2	4.5	2.8
2 Eye height	155.1	4.5	2.9	153.1	5.6	3.7	150.6	4.6	3.1
3 Chin height	143.9	4.4	3.1	142.2	5.0	3.5	139.7	4.5	3.2
4 Acromial height	137.3	4.2	3.1	134.4	4.9	3.6	133.3	4.0	3.0
5 Elbow height	102.5	3.7	3.6	100.8	4.4	4.4	99.8	4.9	4.9
6 Waist height	95.2	3.6	3.8	95.6	4.1	4.3	94.6	3.5	3.7
7 3rd finger height	63.0	3.0	4.8	62.0	2.9	4.7	61.1	2.9	4.7
8 Patella height	44.3	2.1	4.7	44.5	2.9	6.5	43.9	2.0	4.6
9 Med. malleol. height	7.0	0.6	8.6	6.6	0.4	6.1	6.4	0.4	6.3
10 Sitting height	91.4	2.3	2.5	88.2	2.8	3.2	86.6	2.7	3.1
11 Seat height	42.2	1.8	4.3	42.0	2.1	5.0	41.4	2.0	4.8
12 Seat length	45.6	2.6	5.7	46.5	2.4	5.2	46.0	2.6	5.7
13 Buttock-knee length	55.7	2.5	4.5	56.3	2.7	4.8	55.4	2.4	4.3
14 Thigh height	55.3	2.0	3.6	55.5	2.2	4.0	54.6	2.2	4.0
15 Waist breadth	33.0	1.4	4.2	35.5	1.6	4.8	33.3	1.6	4.8
16 Buttock-leg length	93.1	3.8	4.1	94.1	4.5	4.8	92.9	3.3	3.6
17 Elbow rest height	23.4	2.0	8.5	24.7	1.5	6.1	23.8	1.7	7.1
18 Upper limb length	81.6	3.2	3.9	79.4	3.2	4.0	78.4	3.1	4.0
19 Forearm-hand length	44.4	1.6	3.6	44.9	1.9	4.2	44.3	1.7	3.8
20 Chest depth	21.1	1.2	5.7	21.2	1.5	7.1	21.6	1.5	6.9
21 Waist depth	18.5	1.1	5.9	20.1	3.1	15.4	21.3	2.9	13.6
22 Head length	18.5	0.7	3.8	19.0	0.7	3.7	19.1	0.7	3.7
23 Head breadth	15.5	0.7	4.5	15.9	0.6	3.8	15.7	0.5	3.2
24 Interpupil. dist.	6.2	0.3	4.8	6.4	0.4	6.3	6.4	0.4	6.3
25 Bitragion distance	14.1	0.5	3.5	15.3	0.6	3.9	15.2	0.6	3.9
26 Body breadth	42.9	1.6	3.7	42.9	1.8	4.2	42.4	1.7	4.0
27 Biiliaca brim breadth	27.1	1.2	4.4	28.7	1.7	5.9	28.7	1.3	4.5
28 Hip breadth	30.3	1.1	3.6	31.2	1.3	4.2	31.1	1.3	4.2
29 Chest breadth	27.8	1.3	4.7	28.6	1.7	5.9	28.6	1.5	5.2
30 Span akimbo	84.9	2.8	3.3	85.4	3.6	4.2	84.7	3.4	4.0
31 Span	170.4	5.0	2.9	167.3	6.1	3.6	165.7	5.5	3.3
32 Over head reach	210.2	5.4	2.6	208.2	7.4	3.6	204.9	6.6	3.2
33 Foot breadth	9.7	0.5	5.2	9.8	0.4	4.1	9.8	0.4	4.1
34 Foot length	24.6	0.9	3.7	24.3	1.2	4.9	24.1	0.8	3.3
35 Grip diameter	4.4	0.3	6.8	5.0	0.3	6.0	4.9	0.3	6.1
36 Hand length	19.7	0.9	4.6	18.9	0.9	4.8	18.8	0.8	4.3
37 1st finger length	6.7	0.6	9.0	6.8	0.5	7.4	6.8	0.5	7.4
38 2nd finger length	11.8	0.9	7.6	11.8	0.7	5.9	11.8	0.6	5.1
39 Neck	36.7	1.6	4.4	37.0	1.6	4.3	36.5	1.9	5.2
40 Chest girth	89.6	3.8	4.2	87.8	4.3	4.9	87.5	4.5	5.1
41 Weight	62.5	5.1	8.2	61.2	6.9	11.3	59.7	7.1	11.9

The unit of numerical values of Nos. 1～40: cm, that of No. 41: kg.

Table 2. Correlation coefficients (r) to body height and regression equation (y=a+bx) by body height (x), by age group

Age group	20～29 (N=100)			30～39 (N=100)			40～49 (N=100)		
Items	r	a	b	r	a	b	r	a	b
1	—	—	—	—	—	—	—	—	—
2	0.93*	−4.5	0.96	0.98°	−14.7	1.02	0.96	−8.3	0.98
3	0.91*	−10.7	0.93	0.96°	9.2	0.92	0.93	−9.5	0.92
4	0.93	−12.3	0.90	0.95	−11.9	0.89	0.94	−4.6	0.85
5	0.89°	−15.4	0.71	0.89°	−17.6	0.72	0.64**	−12.1	0.69
6	0.87°	−24.4	0.72	0.90°	−16.3	0.68	0.80**	−4.3	0.61
7	0.71	−18.4	0.49	0.73	−1.8	0.39	0.60	−0.5	0.38
8	0.60*	−3.9	0.29	0.60*	−8.2	0.32	0.76°°	−9.6	0.33
9	0.24*	2.0	0.03	0.47°°	1.7	0.03	0.46*	−0.1	0.04
10	0.70	28.3	0.38	0.77	22.4	0.40	0.65	23.0	0.39
11	0.67*	−4.3	0.28	0.81°	−10.7	0.32	0.72	−10.5	0.32
12	0.45	0.7	0.27	0.60	3.8	0.26	0.42	7.1	0.24
13	0.50*	7.6	0.29	0.71°°	−1.3	0.35	0.41*	18.2	0.23
14	0.69	3.8	0.31	0.72	2.9	0.32	0.75	−3.7	0.36
15	0.44°	9.8	0.14	0.22	23.6	0.06	0.14*	25.2	0.05
16	0.60*	5.0	0.53	0.76°°	−11.2	0.64	0.59*	16.8	0.47
17	0.00	18.4	0.03	−0.01	26.4	−0.01	0.00	20.5	0.02
18	0.59	10.1	0.43	0.69	11.9	0.41	0.67	3.8	0.46
19	0.64*	6.1	0.23	0.80°	0.6	0.27	0.72	−1.1	0.28
20	0.00	17.8	0.02	0.00	18.0	0.02	0.20	11.8	0.06
21	0.24	8.5	0.06	0.14	11.9	0.05	0.00	14.8	0.04
22	0.14	15.1	0.02	0.14	17.4	0.01	0.00	17.5	0.01
23	0.00*	15.5	0.00	0.37°	9.3	0.04	0.10	14.1	0.01
24	0.14	4.5	0.01	0.20	4.8	0.01	0.20	4.8	0.01
25	0.10*	12.4	0.01	0.43°°	8.7	0.04	0.14*	13.6	0.01
26	0.38	19.7	0.14	0.22	31.3	0.07	0.22	27.8	0.09
27	0.38	8.8	0.11	0.50	7.4	0.13	0.30	35.3	−0.04
28	0.33	17.0	0.08	0.46	13.0	0.11	0.31	18.1	0.08
29	0.38°	9.5	0.11	0.00*	25.3	0.02	0.26	14.0	0.09
30	0.72	8.4	0.46	0.70	9.7	0.46	0.60	11.7	0.45
31	0.76	20.8	0.90	0.85°	11.0	0.95	0.71*	24.7	0.87
32	0.89	9.1	1.21	0.88	9.1	1.21	0.88	−5.9	1.30
33	0.37	3.1	0.04	0.37	6.5	0.02	0.30	6.6	0.02
34	0.63*	4.6	0.12	0.78°	1.2	0.14	0.64	6.3	0.11
35	0.41*	−0.5	0.03	0.66°	0.0	0.03	0.51	0.0	0.03
36	0.54	1.4	0.11	0.60	4.1	0.09	0.50	5.9	0.08
37	0.00*	5.0	0.01	0.42°°	0.2	0.04	0.00*	6.8	0.00
38	0.28*	3.5	0.05	0.56°	0.3	0.07	0.38	3.7	0.05
39	0.20	25.0	0.07	0.24	25.5	0.07	0.10	30.0	0.04
40	0.33	43.0	0.28	0.14	68.0	0.12	0.26	43.7	0.27
41	0.60°	−48.9	0.67	0.34*	−9.6	0.43	0.40	−44.1	0.64
No. *	14			3			11		
°	5			21			2		

The regression equation should not be used when r is below 0.26.

°: Coefficient is significantly larger than that of *.

°°: Coefficient is significantly larger than both of *.

**: Coefficient is significantly smaller than that of °° or those of °, *. (p=5%)

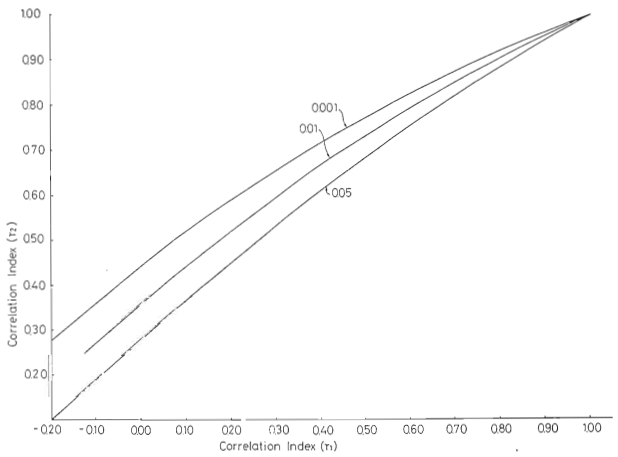

Fig. 3. Test curves on Significance of Difference between two Correlation Coefficients, where $n_1=n_2=100$, $r_2>r_1$, level of significance (P= 0.001, 0.01, 0.05). Significance of difference is acknowledged above the curve, but no significance below the curve.

thirties among which measures showing the highest correlation were the eye height (2) (r=0.98) and the chin height (3) (r=0.96) in the age group of thirties.

Measures showing a higher correlation were the length such as acrominal height (4), elbow height (5), waist height (6), sitting height (10), seat height (11), thigh height (14), buttock-leg length (16), foot length (34), and upper limb length (18), and the girth such as waist depth (21) and span akimbo (30) (r=0.60 to 0.79). Further, the measures such as head length (22), head breadth (23), interpupillary distance (24), bitragion distance (25), body breadth (26), first finger length (37), elbow rest height (17), neck (39), and medial malleolus height (9) did not show respectively any significant correlation (r=0.26 or less).

The measures showing a low correlation were chest breadth (29), foot breadth (33), and chest (40) (r=0.28 to 0.38), but there were found no correlations with the measures of head length and bitragion distance, those of the breadth growth such as body breadth (26) and chest breadth (29), and those of foot and finger.

In comparing the correlation with respect to body length according to difference in age, the measures showing a higher correlation than that in other age groups (Table 2) were five items of elbow height (5), waist height (6), waist breadth (15), chest breadth (29), and weight (41) in the age group of twenties, and mainly the length growth of limbs such as medial malleolus

Table 3. Correlation coefficients to body weight and regression equation (y=a+bx) by body weight (x), by age group

Age group	20～29 (N=100)			30～39 (N=100)			40～49 (N=100)		
Items	r	a	b	r	a	b	r	a	b
1	0.60°°	133.1	0.53	0.34*	148.0	0.27	0.40*	150.2	0.20
2	0.53°	123.3	0.51	0.28*	138.7	0.24	0.40	135.2	0.26
3	0.55	111.9	0.51	0.34	126.6	0.25	0.40	124.9	0.25
4	0.59°	105.6	0.51	0.38	117.8	0.27	0.36*	121.4	0.20
5	0.55	76.9	0.41	0.33	87.9	0.21	0.34	89.4	0.17
6	0.53°°	69.6	0.41	0.28*	85.2	0.17	0.24*	87.5	0.12
7	0.37	46.5	0.26	0.24	55.9	0.10	0.28	54.5	0.11
8	0.38	34.3	0.16	0.30	38.8	0.09	0.33	38.5	0.09
9	0.10	−3.0	0.16	0.10	6.6	0.00	0.30	5.9	0.01
10	0.44	77.7	0.22	0.20	83.3	0.08	0.34	78.9	0.13
11	0.30	35.3	0.11	0.28	36.4	0.09	0.24	37.9	0.06
12	0.28	36.3	0.15	0.42	37.9	0.14	0.34	38.2	0.13
13	0.28	46.3	0.15	0.47	45.3	0.18	0.40	47.7	0.13
14	0.66	24.6	0.49	0.58	43.9	0.19	0.57	43.9	0.18
15	0.69	21.1	0.19	0.70	24.2	0.15	0.63	25.5	0.13
16	0.36	75.6	0.28	0.43	76.3	0.29	0.36	82.8	0.17
17	0.00	23.4	0.00	0.00	25.3	−0.01	0.00	23.2	0.01
18	0.50	61.6	0.32	0.38	68.3	0.18	0.34	69.4	0.15
19	0.52°	33.8	0.17	0.20*	41.9	0.05	0.37	38.9	0.09
20	0.37**	16.1	0.08	0.66°	12.7	0.14	0.76°	12.6	0.15
21	0.46**	12.3	0.10	0.68°	1.7	0.30	0.75°	3.5	0.30
22	0.22	16.6	0.03	0.34	17.2	0.03	0.24	17.9	0.02
23	0.22	13.6	0.03	0.33	14.6	0.02	0.41	13.9	0.03
24	0.10	6.2	0.00	0.28	5.8	0.01	0.30	5.8	0.01
25	0.34	12.2	0.03	0.36	13.4	0.03	0.44	13.4	0.03
26	0.66	29.8	0.21	0.70	32.4	0.17	0.78	31.0	0.19
27	0.55	18.3	0.14	0.68	20.2	0.14	0.56	22.8	0.10
28	0.50*	23.4	0.11	0.72°	23.1	0.13	0.68	24.5	0.11
29	0.62*	17.8	0.16	0.64	20.2	0.14	0.78°	19.1	0.16
30	0.55	65.5	0.31	0.41	68.2	0.28	0.41	72.7	0.20
31	0.54°	134.2	0.58	0.42	144.6	0.37	0.30*	147.6	0.31
32	0.47	175.0	0.56	0.34	184.9	0.38	0.40	178.3	0.44
33	0.46	7.2	0.04	0.45	8.6	0.02	0.47	8.6	0.02
34	0.51	18.9	0.09	0.34	21.2	0.05	0.34	22.4	0.03
35	0.22	3.8	0.01	0.14	0.7	0.07	0.00	3.1	0.03
36	0.50	14.1	0.09	0.34	16.4	0.04	0.28	17.0	0.03
37	0.14	6.1	0.01	0.20	6.2	0.01	0.20	6.2	0.01
38	0.31	8.7	0.05	0.24	10.6	0.02	0.26	10.6	0.02
39	0.63*	24.8	0.19	0.78°	26.6	0.17	0.76	25.1	0.19
40	0.64**	58.9	0.49	0.80°	57.8	0.49	0.87°	54.7	0.55
41	—	—	—	—	—	—	—	—	—
No. *	9			4			4		
°	8			5			4		

The regression equation should be used when r is below 0.26.

height (9), buttock-knee length (13), buttock-leg length (16), bitragion distance (25), and first finger length (37), and reached 16 items in total in the age group of thirties. In the age group of forties, the measures showing a higher correlation than that in the age group of twenties or thirties was only one of patella height, and the measures in nine items showed a lower correlation than those in the other age groups (Table 2).

2. Correlation between weight and each of measures for other 40 items (Table 3):

In this correlation, all of the measures showed a positive correlation, among which the measures showing a higher correlation (r=0.6) were seven items such as chest depth (20) (r=0.76), waist depth (21) (r=0.75), body breadth (26) (r=0.78), biiliaca brim breadth (27) (r=0.68), chest breadth (29), neck (39), and chest (40) in the age group of forties, nine items such as chest (r=0.80) and so forth in the age group of thirties, and seven items such as waist breadth (15) (r=0.69) and so forth in the age group of twenties. On the other hand, the measures which show the correlation less than (r=0.26), namely, those which are considered to have no correlatoin, were elbow rest height (17), medial malleolus height (9), grip diameter (35), and first finger length (37).

In comparing the correlation with respect to weight according to the difference in age, six items belonging to the length growth such as body weight (1), waist height (6), upper limb length (18), and so forth in the age group of twenties showed a correlation higher than in the age groups of thirties and forties, but six items according to the breadth growth and girth growth such as chest depth (20), waist depth (21), biiliaca brim breadth (27), chest (40), and so forth in the age group of twenties showed a correlation lower than those in the age groups of thirties and forties.

In the age groups of thirties and forties, the correlation in these groups showed qutie a reverse tendency, namely, the age group of thirties and forties showed a correlation higher than that in other age groups with respect to five items belonging to the breadth growth and the girth growth such as chest depth (20), waist depth (21), hip breadth (28), neck (39), and chest (40), and the age group of forties showed a correlation higher than that in the other age groups with respect to four items such as chest depth (20), waist depth (21), chest breadth (29), and chest (40). On the other hand, the age group of thirties showed a correlation lower than that in the other age groups with respect to four items belonging to the length growth, such as body height (1), eye height (2), waist height (6), and forearm-hand length (19), and the age group of forties showed a correlation lower than that in the other age groups with respect to four items belonging to the length growth, such as body height (1), acromial height (4), waist height (6),

Table 4. Correlation coefficients (r) to chest girth and regression equation (y=a+bx) by chest girth (x), by age group

Age group	20～29 (N=100)			30～39 (N=100)			40～49 (N=100)		
Items	r	a	b	r	a	b	r	a	b
1	0.33	140.3	0.29	0.14	146.9	0.20	0.26	138.6	0.27
2	0.28	123.0	0.36	0.14	136.4	0.19	0.26	126.2	0.28
3	0.26	115.1	0.32	0.22	119.2	0.26	0.24	117.8	0.25
4	0.26	109.7	0.31	0.26	108.0	0.30	0.22	115.8	0.20
5	0.26	79.3	0.26	0.10	90.2	0.12	0.17	86.4	0.15
6	0.36	63.0	0.36	0.14	82.4	0.15	0.20	80.7	0.16
7	0.22	49.1	0.15	0.00	60.3	0.02	0.22	37.5	0.27
8	0.20	34.5	0.11	0.20	36.4	0.09	0.24	35.2	0.10
9	−0.17**	8.7	−0.02	0.20°	5.7	0.01	0.24°	4.7	0.02
10	0.17	81.5	0.11	0.00	84.6	0.04	0.17	77.0	0.11
11	0.14	35.0	0.08	0.17	34.9	0.08	0.17	34.5	0.08
12	0.26	30.4	0.17	0.30	31.6	0.17	0.30	31.1	0.17
13	0.17	44.1	0.13	0.37	36.1	0.23	0.34	39.7	0.18
14	0.30	41.8	0.15	0.43	35.3	0.23	0.46	34.5	0.23
15	0.51	16.0	0.19	0.54	15.9	0.20	0.51	18.4	0.17
16	0.22	72.5	0.23	0.31	64.3	0.34	0.28	74.5	0.21
17	0.17	31.5	−0.09	0.14	29.1	−0.05	0.00	25.5	−0.02
18	0.28	60.1	0.24	0.36	56.5	0.26	0.33	58.3	0.23
19	0.38	30.1	0.16	0.30	33.5	0.13	0.28	34.7	0.11
20	0.44**	8.6	0.14	0.74°	−0.6	0.25	0.79°	−1.2	0.26
21	0.22**	13.2	0.06	0.66°	−22.1	0.48	0.69°	−17.3	0.44
22	0.10	16.7	0.02	0.34	14.6	0.05	0.36	14.7	0.05
23	0.20	12.8	0.03	0.22	13.3	0.03	0.26	13.1	0.03
24	0.10	5.3	0.01	0.22	5.5	0.01	0.20	5.5	0.01
25	0.34	10.5	0.04	0.26	12.6	0.03	0.34	11.7	0.04
26	0.58*	20.5	0.25	0.67	20.0	0.26	0.78°	16.1	0.30
27	0.28**	19.0	0.09	0.56°	12.9	0.18	0.59°	13.9	0.17
28	0.31*	22.2	0.09	0.51	17.0	0.16	0.60°	17.1	0.16
29	0.57**	9.9	0.20	0.80°	3.1	0.29	0.82°	5.0	0.27
30	0.34	61.6	0.26	0.17	72.1	0.15	0.36	61.0	0.27
31	0.40	121.2	0.55	0.31	126.9	0.46	0.30	132.5	0.38
32	0.26	176.2	0.38	0.24	170.4	0.43	0.30	166.4	0.44
33	0.26	7.0	0.03	0.00	2.8	0.08	0.10	−7.7	0.20
34	0.36	17.4	0.08	0.14	21.6	0.03	0.20	21.5	0.03
35	0.00	3.6	0.01	0.00	1.5	0.04	0.00	0.5	0.05
36	0.34	12.5	0.08	0.22	15.4	0.04	0.28	14.5	0.05
37	0.14	4.9	0.02	0.14	5.9	0.01	0.26	5.0	0.02
38	0.26	6.5	0.06	0.17	10.1	0.02	0.17	9.1	0.03
39	0.56	16.1	0.23	0.70	15.9	0.24	0.69	12.8	0.27
40	—	—	—	—	—	—	—	—	=
41	0.64**	−14.5	0.86	0.80°	−54.7	1.32	0.87°	−61.1	1.38
No.	* 14			0			0		
	° 0			6			8		

The regression equation should not be used when r is below 0.26.

Table 5. Correlation coefficients (r) to sitting height and regression equation (y=a+bx) by sitting height (x), by age group

Age group	20～29 (N=100)			30～39 (N=100)			40～49 (N=100)		
Items	r	a	b	r	a	b	r	a	b
1	0.70	48.3	1.29	0.77	32.3	1.50	0.65	66.9	1.10
2	0.61	49.0	1.16	0.75	18.2	1.53	0.60	60.5	1.04
3	0.63	41.3	1.12	0.70	27.5	1.30	0.57	57.3	0.95
4	0.60	38.6	1.08	0.70	21.6	1.28	0.56	60.4	0.84
5	0.58	22.1	0.88	0.67	6.5	1.07	0.52	40.6	0.68
6	0.44	32.1	0.69	0.54	23.4	0.82	0.31	58.3	0.42
7	0.48	6.3	0.62	0.38	9.5	0.60	0.50	15.1	0.53
8	0.28	19.7	0.27	0.52°	9.9	0.39	0.24*	28.3	0.18
9	0.20	3.3	0.04	0.14	−19.0	0.29	0.38	2.1	0.05
10	—	—	—	—	—	—	—	—	—
11	0.26	23.0	0.21	0.46	10.2	0.36	0.26	23.3	0.21
12	0.24	20.0	0.28	0.20	30.7	0.18	0.10	53.8	−0.09
13	0.26	28.3	0.30	0.36°	25.5	0.35	0.00*	59.8	−0.05
14	0.33	30.6	0.27	0.37	28.2	0.31	0.31	32.1	0.26
15	0.28	17.5	0.17	0.20	22.9	0.12	0.26	19.5	0.16
16	0.20	62.1	0.34	0.33°	45.6	0.55	0.00*	86.5	0.08
17	0.30	−0.4	0.26	0.22	13.2	0.13	0.31	6.4	0.20
18	0.31	43.1	0.42	0.41	37.9	0.47	0.33	44.6	0.39
19	0.30	25.2	0.21	0.50	15.9	0.33	0.28	28.7	0.18
20	0.00	21.9	−0.01	0.00	21.2	−0.00	0.00	18.1	0.04
21	0.00	14.9	0.04	−0.14	34.2	−0.16	0.00	17.0	0.05
22	0.20	13.0	0.06	0.10	16.4	0.03	0.17	15.6	0.04
23	0.00*	13.5	0.02	0.34°	9.7	0.07	0.10	11.5	0.05
24	0.26	3.5	0.03	0.14	4.7	0.02	0.28	3.8	0.03
25	0.00*	13.2	0.01	0.38°°	8.2	0.08	0.10*	13.5	0.02
26	0.31	23.7	0.21	0.10	37.5	0.06	0.22	30.3	0.14
27	0.30	12.5	0.16	0.30	14.6	0.16	0.26	18.3	0.12
28	0.22	20.2	0.11	0.31	17.9	0.15	0.31	18.1	0.15
29	0.17	18.6	0.10	0.00	19.5	−0.01	0.00	25.1	0.04
30	0.43	39.1	0.50	0.40	42.1	0.49	0.31	50.0	0.40
31	0.34	102.6	0.74	0.53	62.4	1.19	0.33	106.0	0.69
32	0.47	98.7	1.22	0.63	60.1	1.68	0.47	101.8	1.19
33	0.30	5.1	0.05	0.30	6.3	0.04	0.20	8.1	0.02
34	0.42	11.8	0.14	0.53	7.5	0.19	0.38	14.6	0.11
35	0.17*	1.7	0.03	0.47°°	0.6	0.05	0.14*	4.1	0.01
36	0.28	9.6	0.11	0.41°	7.4	0.13	0.14*	15.4	0.04
37	0.17	1.3	0.06	0.36	0.6	0.07	0.22	3.3	0.04
38	0.00*	10.0	0.02	0.37°	3.9	0.09	0.20	8.3	0.04
39	0.10	29.3	0.08	0.17	29.1	0.09	0.14	27.0	0.11
40	0.17	63.9	0.28	0.00	78.9	0.10	0.17	60.7	0.31
41	0.44	−21.7	0.92	0.20	14.4	0.53	0.34	−19.1	0.91
No. *	4			0			6		
°	0			10			0		

The regression equation should not be used when r is below 0.26.

and span (31).

3. Correlation between chest and each of measures for other 40 items (Table 4):

In this correlation, the measures showing the highest correlation in the age group of forties were weight (41) ($r=0.87$) and chest depth (20) ($r=0.79$), and the measures showing a higher correlation were the girth growth such as waist depth (21) and neck (39), and the breadth growth, such as body breadth (26) and chest breadth (29). Contrary to this, the measures to be considered to have no correlation ($r<0.26$) were the length growth such as eye height (2), chin height (3), acromial height (4), elbow height (5), waist height (6), and sitting height (10), as well as measures of head and face and also measure of fingers.

In comparing the correlation with respect to chest according to the difference in age, the age group of twenties had no measure showing a correlation higher than that in the other age groups, but the measures showing a lower correlation were eight items belonging to the breadth growth, and girth growth, such as medial malleolus height (9), chest depth (20), waist depth (21), body breadth (26), hip breadth (28), biiliaca brim breadth (27), chest breadth (29), and weight (41). However, in the age group of thirties, the elements of measures showing the correlation were contrary to those in the age group of twenties, namely, measures showing a high correlation were six items belonging to the breadth growth and the girth growth, such as medial malleolus height (9), chest depth (20), waist depth (21), hip breadth (28), chest breadth (29), and weight (41), but there was found no measure showing a low correlation. Further, in the age group of forties, there was a tendency similar to that in the age group of thirties, namely, the measures showing a correlation higher than that in the age group of twenties or thirties were eight items belonging to the girth growth and breadth growth such as medial malleolus height (9), chest depth (20), waist depth (21), body breadth (26), biiliaca brim breadth (27), hip breadth (28), chest breadth (29), and weight (41), and it is an interesting fact that there was found no measure showing a low correlation in the age group of forties as in the case of the age group of thirties.

4. Correlation between seat height and each of measures for other 40 items (Table 5):

In this correlation, all is lower than the correlation with respect to body height except the correlation with respect to elbow rest height (17). The correlation with respect to other measures is almost the same with only a low numerical value. That is, the correlation with respect to the length growth is high, in which the highest is the correlation with respect to body

height in the age group of thirties (r=0.77). On the other hand, the measures showing a lower correlation are buttock-knee length (13), thigh height (14), waist breadth (15), buttock-leg length (16), seat height (11), biiliaca brim breadth (27), foot length (34), and foot breadth (33), which are all concerned with the leg.

In comparing the correlation with respect to sitting height according to the difference in age, it can be said that the tendency in the correlation with respect to body height applies also to the correlation between sitting height and other measures. That is, the correlation in the age group of thirties shows the highest tendency, and that in the age groups of twenties and forties shows a low tendency. When observing more minutely, there is no measure showing a high correlation in the age group of twenties, and the measures showing a low correlation are four items such as second finger length (38), head breadth (23), bitragion distance (25), and grip diameter (35). On the other hand, in the age group of thirties, eight items such as patella height (8), buttock-knee length (13), head breadth (23), buttock-leg length (16), bitragion distance (25), grip diameter (35), hand length (36), and second finger length (38), respectively showed a higher correlation than that in the age groups of twenties and forties, and there was found no low correlation therein. However, in the age group of forties, the order of correlation became contrary again and showed the aspect in the age group of twenties, although some items were different in the detailed observation.

5. Correlation between buttock-leg length and each of measures for other 40 items (Table 6):

In the same way as in the case of correlations with respect to seat height (11) and body height (1), the correlations with respect to the length growth is high, in which the highest one was waist height (6) (r=0.81) in the age group of thirties, and in which a higher correlation was found with respect to seat length (12), seat height (11), and thigh height (14) having a relation to buttock-leg length (16), as well as forearm-hand length (19) and overhead reach (32). On the other hand, measures to be considered to have no correlation ($r<0.26$) are those with respect to head, feet, and fingers, and two items belonging to the breadth growth such as chest breadth (29) and chest (40), as well as sitting height (10) and elbow rest height (17).

In the correlation between buttock-leg length (16) and measures for other items, the buttock-leg length (16) showed a higher correlation with respect to the measures having a relation to leg, but in the correlation with the measures for other items, it showed almost the same tendency as the correlation with respect to sitting height. Further, in the correlation with respect to buttock-leg length (16), the characteristic features appeared more

Table 6. Correlation coefficients (r) to buttock-leg length and regression equation (y=a+bx) by buttock-leg length (x), by age group

Age group	20～29 (N=100)			30～39 (N=100)			40～49 (N=100)		
Items	r	a	b	r	a	b	r	a	b
1	0.60*	101.9	0.69	0.76°°	78.9	0.91	0.59*	94.0	0.73
2	0.56*	90.9	0.69	0.75°	65.5	0.93	0.65	73.1	0.83
3	0.58*	78.5	0.70	0.76°	62.1	0.85	0.61	69.6	0.75
4	0.61	73.1	0.69	0.75	56.4	0.83	0.63	67.0	0.71
5	0.62	46.7	0.60	0.71	36.8	0.68	0.57	48.2	0.55
6	0.66*	32.8	0.67	0.81°°	26.0	0.74	0.67*	34.9	0.64
7	0.46	27.5	0.38	0.56	32.3	0.32	0.37	31.3	0.32
8	0.51*	18.1	0.28	0.70°	14.2	0.32	0.68	9.3	0.37
9	0.10	6.0	0.01	0.00*	3.8	0.03	0.30°	3.6	0.03
10	0.20	79.8	0.12	0.33°	63.6	0.26	0.00*	81.9	0.05
11	0.60*	12.3	0.32	0.78°°	8.1	0.36	0.57*	11.5	0.32
12	0.82	−5.7	0.55	0.77	6.0	0.43	0.74	−3.5	0.53
13	0.86	−1.3	0.61	0.81	9.2	0.50	0.85	−0.3	0.60
14	0.62	25.4	0.32	0.77	18.8	0.39	0.67	16.3	0.41
15	0.33°	21.8	0.12	0.24	25.0	0.09	0.00*	29.6	0.04
16	—	—	—	—	—	—	—	—	—
17	0.00	22.3	0.01	0.17	30.4	−0.06	0.10	29.4	−0.06
18	0.40*	49.9	0.34	0.64°	37.0	0.45	0.50	36.3	0.45
19	0.51*	23.9	0.22	0.71°	17.6	0.29	0.64	15.4	0.31
20	0.14	17.4	0.04	0.22	14.6	0.07	0.28	9.4	0.13
21	0.26	12.0	0.07	0.10	12.5	0.08	0.10	11.0	0.11
22	0.10	16.6	0.02	0.14	17.1	0.02	0.00	19.1	0.00
23	0.00*	15.5	0.00	0.30°°	13.0	0.03	0.00*	14.8	0.01
24	0.10	6.2	0.00	0.20	5.5	0.01	0.10	5.5	0.01
25	0.00*	14.1	0.00	0.31°	11.5	0.04	0.14	13.3	0.02
26	0.26	32.7	0.11	0.37	28.7	0.15	0.20	33.0	0.10
27	0.31*	16.9	0.11	0.59°°	11.8	0.18	0.28*	18.5	0.11
28	0.33*	21.0	0.10	0.47°°	18.9	0.13	0.33*	19.9	0.12
29	0.24	20.4	0.08	0.28	19.2	0.10	0.20	19.3	0.10
30	0.50*	50.5	0.37	0.70°°	34.5	0.54	0.44*	44.4	0.43
31	0.55*	99.3	0.76	0.74°°	73.2	1.00	0.53*	90.0	0.81
32	0.64	117.8	0.99	0.74	93.4	1.22	0.65	93.7	1.19
33	0.00*	9.7	0.00	0.36°	7.9	0.02	0.17	7.9	0.02
34	0.31*	18.1	0.07	0.66°°	11.1	0.14	0.42*	15.7	0.09
35	0.20*	3.5	0.01	0.51°	2.1	0.03	0.37	2.1	0.03
36	0.34	12.3	0.08	0.50	10.4	0.09	0.50	8.5	0.11
37	0.00	5.8	0.01	0.26	3.9	0.03	0.10	5.8	0.01
38	0.14*	9.1	0.03	0.44°	6.2	0.06	0.24	8.0	0.04
39	0.20	29.2	0.08	0.34	26.6	0.11	0.14	28.1	0.09
40	0.22	68.1	0.23	0.31	59.5	0.30	0.28	50.2	0.40
41	0.36	17.8	0.48	0.43	−1.6	0.67	0.36	−13.1	0.78
No. *	18			1			11		
°	1			28			1		

The regression equation should not be used when r is below 0.26.

distinctly according to the difference in age. That is to say, in the age group of thirties, there was a higher correlation than in the age group of twenties or forties in 19 items belonging to the length, breadth, and girth growth, such as body height (1), eye height (2), chin height (3), acromial height (4), waist height (6), patella height (8), sitting height (10), seat height (11), upper limb length (18), forearm-hand length (19), head breadth (23), bitragion distance (25), biiliaca brim breadth (27), hip breadth (28), span akimbo (30), span (31), foot breadth (33), foot length (34), grip diameter (35), and second finger length (38). On the other hand, a low correlation was shown with respect to only medial malleous height (9).

The age group of twenties showed a higher correlation coefficient than the age groups of thirties and forties only with regard to the waist breadth (15) but a lower correlation coefficient with regard to 18 items of body height (1), eye height (2), chin height (3), waist height (6), patella height (8), seat height (11), upper limb length (18), forearm-hand length (19), head breadth (23), bitragion distance (25), biiliaca brim breadth (27), hip breadth (28), span akimbo (30), span (31), foot breadth (33), foot length (34), grip diameter (35), and second finger length (38).

The age group of forties showed a higher correlation coefficient than the age groups of twenties and thirties only with regard to the medial malleolus height (9) but lower correlation coefficients with regard to a number of items of measurement such as waist height (6), sitting height (10), seat height (11), waist breadth (15), head breadth (23), biiliaca brim breadth (27), hip breadth (28), span akimbo (30), span (31), and foot length (34).

General Discussion

The values obtained by the present measurement of various parts of the human body including height, weight, chest girth, and sitting height are slightly higher than the values given in the National Nutrition Survey of 1965 in the age group of twenties with regard to all the items measured, and the results of the measurement show that all the age groups are in a better state. The same goes for the values for those in the age group of thirties though they are less than for the twenties except for the chest girth and leg length. With the age group of forties, the values become smaller. In other words, the measured values become smaller with older generations and the younger generations are in a better state with regard to growth both in lengths and breadths. The results of measurement for the age group of twenties are better in body weight and chest girth than the measures of the university or college students as given in the School Health Statistics by the Ministry of Education of 1965[9] (Table 7), though slightly lower in height.

Table 7. Four principal measures of the present author in comparison with those of other groups

Subjects	Age	Body height		Body weight		Sitting height		Chest girth	
		x	σ	x	σ	x	σ	x	σ
Present author's	20～29	166.2	4.3	62.5	5.1	91.4	2.3	89.6	3.8
	30～39	164.5	5.4	61.2	6.9	88.2	2.8	87.8	4.3
	40～49	162.2	4.5	59.7	7.1	86.6	2.7	87.5	4.5
National Nutrition Survey	20～29	163.7	5.9	56.9	6.4	89.3	3.4	86.4	4.9
	30～39	162.4	5.9	57.0	7.2	88.6	3.4	87.1	5.1
	40～49	160.5	6.1	56.5	7.5	87.7	3.4	87.0	5.2
School Health Statistics	20～24	167.1	5.4	57.9	6.2	90.9	3.2	86.3	4.6

However, it may be safe to considere that the measures for each age group represent those of a typical Japanese male of the corresponding age group since they show no great difference from the results of the National Nutrition Survey or of the university students. A study of variability of observation of each measure (Table 1) in terms of coefficient of variation reveals that measures of lengths such as height (1), sitting height (10), and overhead reach (32) have the lowest coefficient of variation. Among others, the sitting height for the age group of twenties shows the lowest coefficient of 2.5%. On the contrary, the coefficients of the grip diameter (35), the first finger length (37), body weight (41), and waist depth (21) are relatively large, in which both the waist depth and the body weight exceed 15% and become greater with older age groups, the waist depth of the age group of thirties showing a value of 15.4%. In other words, measures which show the least difference among the individuals are lengths such as standing and sitting heights, while measures in volume such as waist depth and the body weight show a greater difference. The coefficients of variation of the various measures shown are slightly smaller or more than even those of the Japanese males in general, so that they are convenient for the study of correlationship between various measures.

The correlation coefficients between various measures have been calculated and shown in Tables 2–6, using the standing and sitting heights and leg length as measures of length, chest as a measure of breadth, and the body weight as a measure of volume. It is considered natural that the correlation between the measures in lengths or between the measures in breadths is relatively large. Among the height, sitting height and leg length which represent the measures in length, the height shows the strongest correlation with the measures of other parts of the body, followed by the sitting height

Table 8. Comparison of correlation coefficients from various origins

	Body height			Body weight			Sitting height			Chest girth		
	A	B	C	A	B	C	A	B	C	A	B	C
Body height				.52	.56	.45	.83	.72	.71	—	.18	.23
Body weight	.52	.56	.45				.51	.49	.33	—	.18	.23
Sitting height	.83	.72	.71	.51	.49	.33				—	.11	.23
Chest girth	—	.18	.23	—	.68	.77	—	.11	.12			

A — Japanese National Railways
B — Kubota, T.
C — Present author

and then by the leg length. With regard to correlation between the measures in breadth and other measures, the chest has low correlation with the height but has high correlation with the weight as a measure of volume. The chest is thus considered to belong to the sphere of the volumetric growth. The measures which have almost no correlation with the height, weight, chest girth, sitting height, and the leg length shown are the medial malleolus height (9), head length (22), interpupillary distance (24), and first finger length (37). Table 8 shows these correlations in comparison with those given in the data issued from the Japanese National Railway Labour Science Research Institute[10] in 1967 and also to the data prepared by Kubota[2,3] of our Department in 1960. It will be seen from this table that the correlation between the measures of various parts of the body of the Japanese males remained almost the same though the measurements were made at different periods. Therefore, it is considered that the correlation between the various measures as given may be used over a long period of time as reference data in the study of human engineering.

From the correlation by age group, the height shows a high correlation with other measures, though it is natural that the growth in length has a strong correlationship. It is interesting to find, however, that the age group of thirties shows an especially high correlation while the correlation becomes lower in the age group of forties. It is considered that the age group of thirties has been influenced by some growth factors in height more strongly than the other age groups of twenties and forties.

With regard to the correlation between the sitting height and other measures, the age group of twenties show higher correlation in the growth in lengths in a way very similar to the correlation between the height and other measures. In this connection, it may seem queer that the sitting height of the age group of twenties has higher correlation with the growth in breadths and the growth in girths than the other age groups. In view of

the fact that the growth in lengths of the age group of thirties show higher correlation than the age groups of twenties and forties, it seems that the age group of hirties have undergone growth in a way different from the other age groups.

Turning now to the correlation between the leg length and other measures, as mentioned in the paragraph concerning the results of measurement, the measured values of the age group of thirties show stronger correlation in almost every item measured than the counterparts in other age groups, save for few exceptions. This fact shows that the body growth in the age group of thirties is lower in height but higher in leg length than the other age groups and is related to the growth of the legs. It should be noted that the relationship between the height and the sitting height of the age group of thirties is unique, that is, the age group of thirties shows higher correlation of the growth in length such as height and sitting height with other measures than the other age groups of twenties and forties. We do not know a definite reason for this phenomenon. However, the difference is supposed to depend on the growth state, the World War II and past War days correspond to the infant period for the twenties, the growing period for the thirties and the adult period for the forties, respectively. It is assumed from this that the age group of twenties were under almost no influence of the war, from the standpoint of physical growth, and the age group of thirties were influenced to a considerable degree, while the influence on the age group of forties is assumed to have been very slight. This may have some connection with the unique correlation between various measures in the age group of thirties.

Further advancing our assumption, the recent rapid improvement of physical conditions of the Japanese males is considered to be represented by the growth of the leg length in the age group of thirties and by the growth of the sitting height in the age group of twenties, taking a complicated form reflecting the difference between the generations.

With regard to the correlation between the weight and other measures, the items of measurement relating to lengths have higher correlation in the age group of twenties, while the measures concerning growth in breadth and girth have higher correlation in the age groups of thirties and forties. This reflects a distinct change which took place in the physical structure for those in thirties, the change occuring especially in the measures such as waist depth and chest depth.

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References

1) Dreyfuss, H.: The measure of man. Whitney Library of Design, New York, 1960.
2) Kubota, T., et al.: A study on the anthropometric measurement of Japanese male adults. (in Japanese, English abstract). Ochanomizu Med. J., 7: 1284–1289, 1959.
3) Kubota, T.: Studies on the correlation among the anthropometric values of male Japanese adults. (in Japanese, English abstract). Japan. J. Hyg., 14: 404–414, 1959.
4) Kita, H., et al.: Ergonomical measurements of human body. (1) Standing and sitting posture measurements. (in Japanese, English abstracts). Ochanomizu Med. J., 17: 25–28, 1969.
5) Kita, H., et al.: Ergonomical measurements of human body. (2) Head and face measurements. (in Japanese, English abstract). Ochanomizu Med. J., 17: 29–32, 1969.
6) Ministry of Health and Welfare, Japan: National nutrition survey. (in Japanese). Ministry of Health and Welfare, Tokyo, 1963.
7) Tachikawa, K.: Reikai-tokeigaku (Exemplified statistics). (in Japanese). Daiichi-Shuppan, Tokyo, 1969.
8) Kubota, T., and Tanaka, S.: A graphical test of the significance of difference between two correlation coefficients. (in preparation).
9) Ministry of Education, Japan: School health statistics. (in Japanese). Ministry of Education, Tokyo, 1965.
10) Kogi, K., et al.: Sagyo-shijimen no Ningen-Kogakuteki Kento no Seitai-Keisokuchi. (Body measurements for ergonomical study of work supporting-surface). Rep. Railway Labour Science Research Inst., Japan National Railways, 67: 1–45, 1967.

Following monographs were referred in preparing this paper.

1) Chiku, A., and Kurata, S.: Kogyo dezain zensho (Engineering design). (5). Kanehara Shuppan, Tokyo, 1962.
2) Kaneko, H., and Kurata, S.: Ningen-kogaku nyumon (Human engineering guidance). (in Japanese). Diamond Co., Tokyo, 1969.
3) Oshima, M.: Ningen-kogaku (Ergonomics). (in Japanese). Asakura Shoten, Tokyo, 1966.
4) Uchimura, Y., and Takeichi, K.: Kikisekkei no tameno jintai-keisokuchi (Human measurements for design of equipment). Ishiyaku Shuppan, Tokyo, 1968.
5) Tsubouchi, K.: Ningen-kogaku (Human engineering). (in Japanese). Nikkankogyo, Tokyo, 1964.
6) Obara, J., et al.: Jintai-keisokuchi zuhyo. (Figures and table of human measurements). (in Japanese). Ishiyaku Shuppan, Tokyo, 1968.