An Anthropometrical Approach to the Turner's Syndrome*

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INTRODUCTION

A syndrome of infantilism, congenital webbed neck and cubitus valgus occurred in the female patients was first described by TURNER in 1938. The similar cases have been studied by SHARPEY-SHAFER ('41), VARNEY et al ('42), ALBRIGHT et al ('42), SCHNEIDER et al ('43), WILKINS et al ('44) and others. The clinical features of the syndrome are characterized by stunted growth, sexual underdevelopment, higher titer of urinary gonadotropin, and primary ovarian insufficiency with the associated congenital defects such as the webbed neck, scoliosis of the spine, eye muscle defects, and so forth. Coarctation of the aorta, unexplained hypertension, and mental retardation are present in a few patients (WILKINS, '57).

An application of the technique by BARR ('49) and DAVIDSON-SMITH ('54) to the syndrome suggested the possibility of discrepancy between phenotypic and genotypic sexes of the patient (POLANI et al, '54; WILKINS et al, '54). The recent studies on human chromosome inspired by TJIO and LEVAN ('56) have led the finding by FORD and his coworkers ('59) that the patient with the syndrome has XO sex chromosome constitution. There followed scores of cases, the karyotype of which showed XO complement. And further cases of XO/XX mosaicism (FRACCARO et al, '60a; FORD, '60; SANDBERG et al, '60; ACHESON et al, '61; FERRIER et al, '61; JACOBS et al, '61), X and X-deletion (JACOBS et al, '60), X and isochromosome X (FRACCARO et al, '60b; JACOBS et al, '61), XO/X and X-deletion mosaicism (CHAPELLE, '62a, '62b), XO/XX/XXX (GRUMBACH et al, '61; ZERGOLLERN et al, '64) and XX/XO/X and X-deletion mosaicism (ASPILLAGO et al, '64) were reported.

The possible phenotypical expressions of the chromosomal variants would be interesting enough in the light of anthropology. Little anthropological study, however, has so far been made on the patients with the syndrome. From 1958 to 1963, we had opportunities to make anthropometric and anthroposcopic investigations on six patients with Turner's syndrome, who had been diagnosed at the Tokyo

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This paper is reverently dedicated to late Professor Emeritus Tsunetaro FUJITA.

University Hospital. The results are herein reported briefly.

PATIENTS: THEIR BRIEF HISTORIES AND CLINICAL DATA

Patient Ka. M. was a phenotypic female, who was measured at the age of 18, April 19, 1958. She was a normal full-term baby and began to walk at about 2 years of age. When she entered a primary school at 7 years, she was already by far retarded in growth. Since then, she had gained only a little in height every year. She had never been ranked above the middle in her school work. She did not complete the second grade course of high school, because rather of the mental suffering due to the ill-treatment by her classmates than of her low attainments. The pattern of her sex chromatin was found negative. Both the uterus and the fallopian tubes were infantile. Neither follicle formation nor hilus cell was found in the ovaries. The B. M. R. was +16% on one occasion and +8% on another. An I. Q. was 88. She had never had any serious illness.

Patient Ky. M. was a phenotypic female, who was measured at the age of 25, May 4, 1961. To our regret, nothing was known except that the sex chromatin was of male type, because the clinical record of the patient was disorderly kept and could not be found.

Patient Y. K. was a phenotypic female, who was measured at the age of 19, July 4, 1962. She was born normal and weighed about 3 kg at birth. From the age of 6 or 7 it was already noticed that she had been smaller than normal children of her age. At the time of her entrance into the junior high school (12 years old), she was markedly retarded in her statural development. However, she did well in her school work consecutively. She had never suffered any serious illness except the venous sinusitis, for which she was operated upon at the second grade of high school (17 years old). The sex chromatin was of male type. The chromosomal analysis showed that she had an XO sex chromosome constitution. Her uterus was about the size of a little finger. The fallopian tubes were 3 to 5 mm in diameter and 5 to 6 cm in length. The urinary excretion of gonadotropin fell within normal range. The B. M. R. was -1%. Her mental development was normal, although childish behaviors were occasionally observed.

Patient K. H. was a phenotypic female, who was measured at the age of 27, July 21, 1962. It is also regrettable that no clinical finding would herewith be described, except that she had an XO sex chromosome constitution, because of the same reason as in the case of patient Ky. M.

Patient R. H. was a phenotypic female, who was measured at the age of 17, August 9, 1962. She was below the average in both height and weight at birth. Her father and mother were also small (158 cm and 148 cm tall respectively). From the time of her third grade of primary school (8 years old), she had been stunted

remarkably in statural growth, and attained 124.6 cm in height at the time of her first grade of high school (15 years old). Since then, little had been gained in height. The sex chromatin of the patient was of male type and the sex chromosome constitution was XO. The uterus was infantile and measured 2.5×0.5 cm. The right ovary was composed of whitish connective tissue and no other structure was found. In the left ovary, however, two primordial follicles were observed. A urinary output of gonadotropin was 96 m. u./day. The secretion of ACTH was considered normal. The B. M. R. was +31%. An I. Q. was 87. The osseous development was that of a 15 years old girl.

Patient S. K. was a phenotypic female, who was measured at the age of 20, August 16, 1963. She was a full-term baby weighing about 2.3 kg. From early infancy, she was small and grew slowly. But she always made fine records at school. Her main complain was an amenorrhoea, short stature and non-appearance of the secondary sex characters. She had never suffered from any serious illness. The chromosomal analysis indicated that her sex chromosome constitution was of XO/XX mosaicism. The secretion of ACTH was considered normal. The B. M. R. was -2%. Her bone age was estimated 18 years.

RESULTS

Somatoscopy with the Aid of Photographs :

Patient Ka. M. (Photo. 1) has a large head in relation to the body, which gives her a childish appearance. Her face is broad and round and the neck appears short due to the slight webbing. Her extremities are somewhat short for the trunk. The proportion of the length of trunk to the width seems normal but the hip is rather small in relation to the shoulder. This reinforces the impression that she lacks feminine features. The subcutaneous fat tissue, however, is well developed. The breasts are infantile and no sexual hair is found. The increased carrying angle of elbow (cubitus valgus) is remarkable.

Patient Ky. M. (Photo. 2) has somewhat large head in relation to the body. Her face is short and oval with pointed chin. The neck appears normal. In proportional point of view, the trunk and extremities seem to be normal. She also lacks such somatic feminine characters as broad hip in relation to shoulder, well-developed fatty tissue and so forth. Her breasts are, as a whole, flat and infantile although the areolae are slightly elevated (Grade B after STRATZ). A few pubic hairs are seen.

Patient Y. K. (Photo. 3) has also large head for the body which gives her a childish appearance. Her face is round and broad. The neck, trunk, and extremities seem to be normally balanced. She reveals little secondary sex characteristics; the breasts are infantile, and no sexual hair has been developed. In addition,

Photo. 5
(Patient S. K.)

Photo. 4
(Patient R. H.)

Photo. 3
(Patient Y. K.)

Photo. 2
(Patient Ky. M.)

Photo. 1
(Patient Ka. M.)

she has narrow hip for the shoulder. Her carrying angle of the elbow is not remarkably increased. The subcutaneous fat tissue is moderately developed.

Patient K. H. can not be described, since the photographs are not available.

Patient R. H. (Photo. 4) has a childish body proportion; large head for the body. She has a broad face as well. Her neck appears somewhat shortened due to the slight webbing. Her increased carrying angle of the elbow is also recognizable. Her extremities especially the arms are short for the trunk. The hip is narrow for the shoulder, but the well-developed fat tissue over trunk and thighs favours a feminine impression. The breasts, however, are infantile and no sexual hair is found.

Patient S. K. (Photo. 5) has less childish head for the body. Her face is oval. A typical webbing makes an appearance that her neck is short. The proportion of the extremities to the trunk is almost normal. The shoulder is broad for the hip, and the thorax is well developed. The increased carrying angle of the elbow is notable. The subcutaneous fat tissue is moderately developed. The breasts are infantile.

Anthropometry :

Anthropometric measurements on six patients are given in table 1. It is to be noted that the patients are similarly stunted in growth of stature for their ages. And general reduction in size is obviously seen. Their statural ages are regarded in both sexes as 9 years for patients Ky. M. and R. H., 10 years for patients Ka. M. and Y. K., and 11 years for patients K. H. and S. K. respectively.

Comparisons are made with four control groups: i) the adult males (NISHI, '52; OSATO, '51), ii) the adult females (NISHI, '52; OSATO, '51), iii) the boys of the age corresponding to the stature of each patient (TOFUKUJI, '57; KIDA et al, '57; OSATO, '52), and the girls of the age corresponding to the stature of each patient (TOFUKUJI, '57; KIDA et al, '57; OSATO, '52). In order to evaluate the significance of the comparisons, t -tests are made according to the following treatments;

$$t = |\bar{\delta} - 0| \sqrt{N/u}, \quad \bar{\delta} = \Sigma \delta_i / N, \quad \delta_i = (x_i - \bar{x}_0) / \sigma_0, \quad u^2 = \Sigma (\delta_i - \bar{\delta})^2 / (N-1),$$

where N is the number of the patients, x_i is the anthropometric measurement of the patient i , $\bar{x}_0$ is the mean of the control group and σ_0 is the standard deviation of the control group. The results of the t -tests are summarized in table 2.

i) *Comparison with the Adult Males* (Fig. 1): All the measurements, in absolute value, are significantly smaller than those of the adult males. Especially, as to the measures of lengths viz. stature, length of trunk, and lengths of upper and lower limbs, the patients are far smaller. Their averages fail to reach even -4σ line of the adult males. The measures of width and girth are less retarded in growth than those of length, although their deviations from the adult males are

Table 1 Anthropometric Measurements on Six Patients

Measures	Patients					
	Ka. M.	Ky. M.	Y. K.	K. H.	R. H.	S. K.
1 Stature	1323	1265	1305	1396	1254	1384
4 Suprasternal Height	1068	1013	1030	1094	974	1111
6 Symphysis Height	658	613	640	668	599	651
8 Acromion Height	1076	999	1034	1114	996	1126
13 Iliospine Height	683	686	693	717	661	736
27 Trunk Length	410	400	390	426	375	460
45 Upper Limb Length	509	556	553	605	542	607
47 Upper Arm Length	243	235	234	245	235	264
48 Forearm Length	156	170	169	202	159	188
49 Hand Length	150	151	150	158	148	155
52 Hand Breadth	70	61	67	69	68	69
a Lower Limb Length	670.5	649.5	666.5	692.5	630.0	693.5
b Thigh Length	341.5	337.5	336.5	379.5	326.0	365.5
56 Leg Length	259	296	271	260	256	264
58 Foot Length	215	197	202	207	202	220
59 Foot Breadth	88	78	80	86	78	82
35 Bi-acromial Breadth	309	313	309	331	315	323
36 Chest Breadth	262	219	238	244	219	242
40 Hip Breadth	236	243	242	253	226	260
37 Chest Depth	145	152	164	167	148	172
61 Chest Girth	735	696	735	753	695	775
62 Waist Girth	609	546	553	608	592	617
65 Upper Arm Girth	224	185	220	220	222	192
66 Forearm Girth	220	185	198	205	200	213
67 Wrist Girth	153	128	144	138	135	145
68 Thigh Girth	438	379	414	398	431	462
69 Calf Girth	305	262	279	268	290	316
70 Ankle Girth	202	172	189	178	191	209
Trunk L./Stature	30.99	31.62	29.89	30.52	29.90	33.24
Upper Limb L./Stature	38.47	43.95	42.38	43.34	43.22	43.86
Upper Arm L./Stature	18.37	18.58	17.93	17.55	18.74	19.08
Forearm L./Stature	11.79	13.44	12.95	14.47	12.68	13.58
Lower Limb L./Stature	50.68	51.34	51.07	49.61	50.24	50.10
Thigh L./Stature	25.81	26.68	25.79	27.18	26.00	26.41
Leg L./Stature	19.58	23.40	20.77	18.63	20.41	19.08
Bi-acromial B./Stature	23.36	24.74	23.68	23.71	25.12	23.34
Hip B./Stature	17.84	19.21	18.54	18.12	18.02	18.79
Hip B./Bi-acromial B.	76.38	77.64	78.32	76.44	71.75	80.50
Chest G./Stature	55.56	55.02	56.32	53.94	55.42	56.00
Waist G./Stature	46.03	43.16	42.38	43.55	47.21	44.58
Upper Limb L./Lower Limb L.	77.36	85.54	82.91	87.30	86.03	85.86
Hand B./Hand L.	46.67	40.40	44.67	43.67	45.95	44.52
Foot B./Foot L.	40.93	39.59	39.60	41.55	38.61	37.27

Table 1 (continued)

Upper Arm G./Upper Arm L.	92.18	78.72	94.02	89.80	94.47	72.73
Thigh G./Thigh L.	133.13	108.91	122.49	105.85	133.85	121.90
45 Head Circumference	539	512	548	558	534	539
16a All Head Height	213	209	202	235	211	204
15 Head Height	125	120	128	137	118	119
1 Head Length	170	173	174	177	165	168
3 Head Breadth	160	145	155	155	151	153
4 Minimum Frontal Breadth	96	97	106	106	110	99
66 Bizygomatic Breadth	135	128	133	136	136	140
8 Bigonial Breadth	109	99	102	98	106	105
18 Total Face Length	117	112	104	128	102	107
21 Nose Height	57	45	45	48	43	49
13 Nose Breadth	33	30	37	31	33	33
Cephalic Index	94.12	83.82	89.08	87.57	91.52	91.07
Facial Index	86.67	87.50	78.20	94.12	75.00	76.43
Nasal Index	57.89	66.67	82.22	64.58	76.74	67.35

a is obtained by halving the sum of Symphysis height (6) and Iliospine height (13).

b is obtained by subtracting Knie height (15) from Lower limb length (a).

significant at less than 5% level. It can be seen that the chests of the patients are comparatively well developed in relation to height. Head and face measurements are also smaller with a moderate degree of significance except for the breadth of head.

The relative lengths of trunk and lower limb to height show lower values, though the deviations are statistically insignificant. This suggests that they would have larger head in proportion to their height. The relative length of upper limb, however, approximates that of the adult males. The measures of width are proportionally very bigger than those of the adult males. In particular, the relative width of hip to height greatly exceeds that of the adult males, and the deviation is highly significant. It is interesting that the ratio of the width of hip to shoulder, which is one of the best measures to express the sex difference, approximates that of the adult males. The relative girth of chest to height adds an evidence to support that the chest of the patients are developed fairly well. The chest index is similar to that of the adult males. The head of the patients are rounder and the face shorter. This might be one of the reasons for the fact that they have the childish appearance.

ii) *Comparison with the Adult Females* (Fig. 2): General reduction in size is also recognized except for the head measurements. In regard to the measures of length, the patients are far smaller than the adult females. The deviation which approaches 3σ is significant at less than 1% level. The measures of width are in

general narrower than those of the adult females. Among them, the hip diameter is the smallest. The shoulder diameter of the patients shows moderately significant deviation from that of the adult females. No significant deviation is found in the chest diameters. In all the measures of girth, the patients are significantly inferior to the adult females. The measurements of head and face are approximately the same with those of the adult females, though there is an indication of broader head.

The relative lengths of trunk and lower limb to height are smaller than those of the adult females, although statistically significant deviation is not found with the trunk ($0.05 < P < 0.10$). The growth of the length of lower limb is included in that of long bones which is mediated by the gonadal steroids. In these patients, however, is lacking the secretion of estrogen which accelerates strongly the closure of the epiphysis of long bones. Therefore, the smaller leg cannot be explained on an endocrine basis. That it is not caused by absence of sex hormones is shown by the fact that patients who are castrated before puberty grow tall and develop eunuchoid proportions (WILKINS, '57). In this respect, other intrinsic factors, e. g., sex chromosome imbalance, might well be proposed to influence the growth of long bones. The relative length of upper limb, however, approximates that of the adult females. This might suggest that the mechanism of the growth of arm and leg would differ from each other.

The relative width of shoulder to height surpasses greatly that of the adult females with less than 0.1% level of significance. As to the relative width of hip, however, the degree of predominance over the adult females is inferior to that of the shoulder. Thus, the hip-shoulder ratios of the patients are scattered on the negative side of fig. 2. It should be noted that the patients have narrower hip in relation to the shoulder than the adult females. From the viewpoint of hip-shoulder relation, it can be said that the patients resemble more to the adult males than to the adult females.

The chest index shows that the patients have more flattened chests than the adult females, although the deviation being insignificant ($0.10 < P < 0.20$). Most of them are plotted on the positive side of fig. 1 and on the negative side of fig. 2, that is, they lie between the averages of the adult males and females. On the other hand, the relative girth of chest surpasses that of the adult females as well as the adult males with a high degree of significance. The relative girth of waist lies slightly above the average of the adult females but the deviation is not significant ($0.05 < P < 0.10$). The cephalic index shows that the patients have broader or rounder heads than the adult females. The values of facial index show rather large variation but fall within $\pm 2\sigma$ of the adult females.

Table 2 Means of Standardized Deviation from Four Control Groups and Their t Values under the Null-hypothesis of $\bar{d}=0$.

Controls Measures	Adult Males		Adult Females		Boys		Girls	
	$\bar{d}$	t	$\bar{d}$	t	$\bar{d}$	t	$\bar{d}$	t
1 Stature	-5.58	13.22***	-3.28	7.92***	0.23	2.54	0.12	1.79
27 Trunk Length	-4.35	9.07***	-2.70	6.70**	0.56	1.49	0.70	1.63
45 Upper Limb Length	-4.44	9.13***	-3.08	6.09**	-0.01	0.02	0.10	0.25
a Lower Limb Length	-4.73	18.87***	-3.64	11.73***	-0.34	2.23	-0.56	5.31**
35 Bi-acromial Breadth	-2.53	15.10***	-0.68	3.66*	2.68	16.02***	2.30	7.11***
36 Chest Breadth	-1.44	3.42*	-0.33	0.98	3.37	4.97**	3.81	5.97**
40 Hip Breadth	-1.64	4.99**	-1.75	6.09**	3.31	12.20***	2.56	10.92***
37 Chest Depth	-1.23	3.61*	-0.76	2.29	1.17	2.67*	1.71	5.37**
61 Chest Girth	-2.12	7.16***	-1.34	4.88**	3.52	18.11***	2.98	12.73***
62 Waist Girth	-2.36	8.25***	-1.44	5.72**	1.39	3.38*	1.92	4.77**
65 Upper Arm Girth	-1.83	4.83**	-1.41	4.21**	3.60	4.44**	2.65	4.07**
68 Thigh Girth	-1.52	3.93*	-1.22	3.66*				
Trunk L./Stature	-0.54	1.31	-0.86	2.27	1.07	1.59	1.59	2.13
Upper Limb L./Stature	-0.32	0.55	-0.45	0.67	0.06	0.06	0.32	0.35
Lower Limb L./Stature	-0.62	2.55	-0.80	3.50*	-0.94	2.35	-1.30	3.01*
Bi-acromial B./Stature	1.28	4.53**	2.01	8.44***	3.00	11.40***	3.54	9.08***
Hip B./Stature	2.78	10.40***	0.65	3.39*				
Hip B./Bi-acromial B.	0.14	0.81	-0.93	5.52**	1.17	4.00*	0.71	2.34
Chest D./Chest B.	-0.06	0.13	-0.62	1.57	-1.17	2.87*	-0.92	2.25
Chest G./Stature	2.05	15.92***	1.07	10.28***	3.64	13.29***	4.57	25.29***
Waist G./Stature	0.77	2.92*	0.54	2.10				
45 Head Circumference	-1.85	4.28**	-0.93	2.34	2.15	4.54**	1.96	5.11**
1 Head Length	-2.08	8.16***	-0.38	1.66	-0.10	0.39	0.40	1.14
3 Head Breadth	-0.36	1.21	0.92	2.52	0.82	2.47	1.44	4.17**
7 Bizygomatic Breadth	-0.71	3.14*	0.32	1.26	1.30	4.02*	2.07	5.92**
18 Total Face Length	-1.58	2.79*	-0.18	0.29	0.42	0.54	1.09	1.22
Cephalic Index	1.35	3.92*	1.04	3.03*	0.49	1.81	0.49	1.76
Facial Index	-0.89	1.76	-0.56	1.14	-0.47	0.62	-0.45	0.57

Three asterisks denote significance less than 0.1% level, two between 0.1 and 1%, and single between 1 and 5%.

iii) *Comparison with the Boys of the Age Corresponding to the Stature of Each Patient* (Fig. 3): The measures of length, which are highly correlated with the stature, approximate those of the corresponding boys, except for the length of lower limb, which seems to show a lower value ($0.05 < P < 0.10$). On the other hand, the measures of width exceed greatly those of the corresponding boys. The depth of chest is statistically bigger at 5% level of significance than that of the

Fig. 2 Comparison with the adult females

Fig. 3 Comparison with the boys of the age corresponding to the stature of each patient

Fig. 4 Comparison with the girls of the age corresponding to the stature of each patient

corresponding boys. The girth of chest surpasses exceedingly that of the corresponding boys. The deviation is about 3.5σ and statistically significant at less than 0.1% level. The other measures of girth as well show larger values than those of the corresponding boys. Head and face measures are generally bigger than those of the boys, though statistical significance is found only in the circumference of head and the bizygomatic breadth.

Proportionally, the length of lower limb is rather smaller ($0.05 < P < 0.10$), while the lengths of upper limb and trunk do not differ statistically from those of the boys. The relative widths of shoulder of the patients fall between $+2\sigma$ and $+4\sigma$ lines of fig. 3, the deviation being statistically significant at less than 0.1% level. The hip-shoulder ratio shows a higher value at less than 5% level of significance than that of the boys. The chest index indicates that the patients have proportionally more flattened chests than the corresponding boys. The relative girth of chest to height, however, exceeds that of the corresponding boys. The facial index of the patients shows comparatively large variance and no significant deviation from that of the corresponding boys can be found.

iv) *Comparison with the Girls of the Age Corresponding to the Stature of Each Patient* (Fig. 4): The lengths of trunk and upper limb of the patients are not different certainly from those of the corresponding girls, while the length of lower limb shows a lower value at less than 1% level of significance. The measures of width as well as girth are far superior to those of the girls, showing that the patients have very well developed trunk in relation to their statural ages. The head and face measurements are in general larger than those of the girls.

The relative length of trunk seems to be longer than that of the girls ($0.05 < P < 0.10$). The relative length of lower limb is rather shorter than those of the girls at less than 5% level of significance, while the relative length of upper limb does not differ statistically from that of the girls. The relative width of shoulder is far greater than that of the girls and the deviation approaching 3.5σ is statistically significant at less than 0.1% level. The hip-shoulder ratio seems to be bigger than that of the girls ($0.05 < P < 0.10$). The chest index shows comparatively lower value ($0.05 < P < 0.10$). The cephalic indices of the patients fall within normal range of the girls. Large variance prevents us from drawing any confirmatory conclusion on the facial index.

DISCUSSION AND CONCLUSION

The human sex comprises essentially three main sexes; genetic or chromosomal, gonadal, and somatic. There are possibilities that the abnormality would occur in every basic sex. The sex chromosome imbalance causes the gonadal and somatic anomalies and the gonadal anomalies cause the somatic disorders. Turner's syn-

drome due to the genetic or sex chromosome aberration should cover the gonadal and somatic variations. FRACCARO et al ('60c) proposed that the term "Turner's syndrome" was to be restricted to those individuals whose sex chromosome constitution was of the XO type. However, gonadal dysgenesis is today neither clinically nor cytogenetically a well-defined syndrome (CHAPELLE, '62b). BAHNER et al ('60) reported a 31 years old woman with XO sex chromosome constitution who had been delivered of a normal boy, while ARIMA et al ('63) claimed that there were unexpectedly more cases with XO complement among mentally defected girls with short stature who had no such symptom as cubitus valgus, pterygium colli, etc. which were considered as the criteria for the diagnosis of the classical Turner's syndrome. Besides, FERRIER et al ('63) pointed out that all degrees of aberrant sexual development may be seen with XX/XO type of mosaicism, from gonadal dysgenesis or true hermaphroditism in phenotypical females to male pseudo-hermaphroditism and simple cryptorchism.

Therefore, it can be said that the gonadal and somatic variability of the syndrome are rather complicated. In this respect the questions are raised firstly whether the patients can be regarded as a homogeneous group concerning the somatic especially morphological variability or not, and secondly whether the somatic features of the patients would tend to converge upon femininity, masculinity, infantility or neither. The first question is answered to some extent by the unbiased variances of standardized deviation (u^2) given in table 3. It is clear that the variance close to 1 means that the patients have almost the same variation with the control. The variance more than 1 denotes that the patients have the larger variation than the control, and the variance less than 1 signifies that the patients have smaller variation than the control. The significant *F*-ratios are 4.36 at 5% level and 9.02 at 1% level under the assumption that the degree of freedom of the control is ∞ . Thus, the variances falling between 0.229 and 4.36 or 0.111 and 9.02 cannot be said to differ from that of the control at 5% or 1% level of significance.

From table 3, it is apparent that the variances of most measurements of the patients fall in the confidence intervals of 5% level of significance. The exceptional measurements are the relative girth of chest (0.099) and the hip-shoulder ratio (0.183) for the comparison with the adult males, the relative girth of chest (0.065) and the hip-shoulder ratio (0.171) for the comparison with the adult females, the stature (0.050), the lower limb length (0.140) and the chest girth (0.227) for the comparison with the corresponding boys, and the stature (0.027), the relative girth of chest (0.187) and the total face length (4.770) for the comparison with the corresponding girls respectively. It is natural that the variance of stature of the patients is significantly smaller than those of both boys and girls, since compari-

sons are made with these boys and girls whose statures approximate most that of each patient. The relative or absolute girth of chest and the hip-shoulder ratio of the patients show significantly smaller variances than those of the adult males and females. Despite of having the female phenotype, the patients with the syndrome are not different from the adult males regarding the hip-shoulder ratio, while the hip-shoulder ratio of the eunuchoidism patients including Klinefelter's syndrome approaches that of the adult females (unpublished data). Taking these

Table 3 Unbiased Variances of Standardized Deviations of the Patients from Four Control Groups

Measures	Adult Males	Adult Females	Boys	Girls
1 Stature	1.067	1.025	0.050**	0.027**
27 Trunk Length	1.383	0.974	0.853	1.097
45 Upper Limb Length	1.422	1.530	1.251	0.990
a Lower Limb Length	0.437	0.577	0.140	0.323
35 Bi-acromial Breadth	0.412	0.456	0.409	0.792
36 Chest Breadth	1.062	0.686	2.767	2.443
40 Hip Breadth	0.645	0.494	0.441	0.329
37 Chest Depth	0.696	0.660	1.156	0.606
61 Chest Girth	0.526	0.453	0.227*	0.329
62 Waist Girth	0.491	0.381	1.012	0.970
65 Upper Arm Girth	0.859	0.674	1.984	1.597
68 Thigh Girth	0.897	0.666		
Trunk L./Stature	1.018	0.863	2.580	3.347
Upper Limb L./Stature	2.061	2.703	2.403	2.226
Lower Limb L./Stature	0.354	0.312	0.959	1.118
Bi-acromial B./Stature	0.478	0.583	0.644	0.954
Hip B./Stature	0.428	0.220		
Hip B./Bi-acromial B.	0.183*	0.171*	0.514	0.552
Chest D./Chest B.	1.299	0.939	1.742	2.175
Chest G./Stature	0.099**	0.065**	0.450	0.187*
Waist G./Stature	0.418	0.394		
45 Head Circumference	1.121	0.953	1.341	0.882
1 Head Length	0.389	0.313	0.390	0.742
3 Head Breadth	0.527	0.797	0.654	0.716
7 Bizygomatic Breadth	0.306	0.389	0.626	0.733
18 Total Face Length	1.920	2.303	3.632	4.770*
Cephalic Index	0.713	0.707	0.439	0.467
Facial Index	1.548	1.449	3.408	3.759

Two asterisks denote significance less than 1% level, and single between 5 and 1%.

facts into consideration, it is well proposed that the hip-shoulder ratio is the index necessary for the study of intersexuality or bisexuality. The smaller vari-

ance of the chest girth is consistent with the fact that the most of the patients are reported to have a shield-like chest (WILKINS, '57). The fact that few measurements indicate the variance more than 1 would suggest that the patients have rather moderate resemblance to each other, and might allow us to consider that the morphological features of the patients are homogeneous.

Of interest, slight different trends are obviously seen between the variances of absolute and relative lengths of upper and lower limbs. The upper limb length of the patients shows larger variance, while the lower limb length shows smaller variance than that of the four controls. Furthermore, there exists a tendency in the lower limb length of the patients to be proportionally shorter than in that of four control groups. But there is no such tendency in the upper limb length. It is also reported that the patients with Klinefelter's syndrome, most of whom have XXY sex chromosome constitution, have abnormally great lower limb length before and after puberty, which is not due to delayed epiphyseal closure but to a greater growth-rate from early age (STEWART et al, '59; TANNER et al, '59). Thus, it is tempting to think that the factors influencing upon the growth of lower limb length and those affecting gonadal differentiation may be closely related.

The second question is thrown some light upon by using the shape distance given by PENROSE ('54). In order to make the comparisons with four control groups possible, the totalled 25, 11 somatic absolute, 7 somatic relative, and 7 head measurements, which are available for all control groups, are chosen for the calculation of the shape distances (Table 4).

Table 4 Shape Distances (PENROSE) from Four Control Groups

Calculation based on	Adult Males	Adult Females	Boys	Girls
Totalled 25 Measurements	3.41	1.80	2.20	2.20
11 Somatic Absolute Measurements	2.15	1.18	2.19	1.75
7 Somatic Relative Measurements	0.87	1.14	2.91	4.11
7 Head Measurements	1.02	0.48	0.66	0.71

It is clear from table 4 that the patients, as a whole, resemble most to the adult females and least to the adult males. This might be rather unexpectedly accepted but is compatible with the facts that the patients are phenotypically female and that XO individuals have a rate of skeletal maturation corresponding to XX (TANNER et al, '59). The comparatively large value of 1.80, however, makes us hesitate to conclude that the patients present a striking resemblance to the adult females. The slight degree of resemblance to the girls suggests that the growth retardation of the patients occurs not abruptly before puberty but gradually from very early age. This is also supported by the past histories of the patients. The similar phenomenon is found in the growth of the patients with Klinefelter's

syndrome; the excess of growth-rate of lower limb length begins from early (TANNER et al, '59).

The shape distances based on the 11 somatic absolute measurements show much smaller value for the comparison with the adult females than for that of the boys and girls, despite of the fact that the comparisons are made with those boys and girls whose stature is closest to that of each patient. It is quite interesting that the shape distances based on the 7 somatic relative measurements indicate the largest value for the comparison with the girls and the smallest one for that with the adult males. In this connection the infantility of the patients may be excluded and the masculinity may well be accepted. This relation has already been seen in the hip-shoulder ratio. The calculation upon 7 head measurements show the greatest resemblance to the adult females, which does not contradict the impression obtained from the photographs that the patients have relatively large (childish) head. As a general conclusion, it can be stated that the patients with the syndrome are morphologically homogeneous and distinguished by the stature short for the age, the head similar to that of the adult females, the body proportion similar to that of the adult males, and the body built as a whole rather unique than feminine.

In addition, the investigation on the abnormal gives a clue to the analysis of the normal. TANNER et al ('59) discussed the role of genes on Y chromosome which control the skeletal maturation by contrasting Klinefelter's (XXY) with Turner's (XO) syndrome. The abnormally long leg, narrow shoulder and broad hip of the patients with Klinefelter's syndrome form a striking contrast to relatively short leg, broad shoulder and narrow hip of our patients with Turner's syndrome. A single X chromosome addition to the normal male would result in Klinefelter's syndrome and a single X chromosome reduction from the normal female would result in Turner's. Therefore, it may be suggested that genes on X chromosome would have some role, more or less, in the growth of lower limb, shoulder, and hip. LYON ('61, '62) who was working with sex-linked coat-color genes of mice proposed the hypothesis that hyperpyknotic X chromosome was genetically inactive, that the inactivation took place in early embryo, and that the same X chromosome remained inactive in the progeny of the cell once the inactivation had occurred. From this hypothesis it might be considered that XO individual equals normal XX and that XXY individual does normal XY. But there exist great phenotypic differences especially in the gonadal differentiation and the somatic features.

A new explanation for Turner's syndrome is proposed on the basis of LYON's hypothesis. GARTLER et al ('63) working on isochromosome X patients with Turner's syndrome assumed that the genetic inactivation must take place in early embryo

of XO individuals too. But two Xs is necessary for the normal female sex decision until about 12-18 days after fertilization, as evidenced by the appearance of the sex chromatin. The existence of a single X or abnormal X, i. e. X-deletion and isochromosome X, in a cell before this time is responsible for the absence of normal gonadal differentiation. Since those XO cells are lethal in which the genetic inactivation of X chromosome has occurred, the cells without inactive X chromosome alone develop into an individual with Turner's syndrome. The great loss of the cells are responsible for the variable somatic anomalies. The evidences, however, have not been found to support the explanation given by GARTLER et al. In any way, further informations are required for the analysis of the relationship between the chromosome and its morphological expressions.

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ターナー氏症候群の身体計測

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本症候群は1938年に H. H. TURNER により 7 人の女性に出現した幼若症、先天性翼状頸、及び外反肘を三徴候とする症候群として初めて記載された。その主な臨床的特徴は性染色体構成の異常—その多くは XO 型又は XO/XX のモザイク型—に伴う短身、生殖腺形成不全、性的発育不全、高尿中ゴナドトロピン量、及び各種の先天性異常（翼状頸、脊柱側弯、楯状胸郭等）等である。又屢々、大動脈狭窄、原因不明の高血圧、知能低下、眼筋異常等の症状も随伴する (WILKINS, '57)。

本症候群の人類学的研究は殆んど知られていない。僅かに TANNER ら ('59) の骨成熟を論じた報告を見るに過ぎない。筆者らは 1958—63 年間に東京大学附属病院に於て診断された 6 例に就いて人類学的検査をする機会を得たので、その結果を報告する。

1) 詳細な身体計測の結果は表 1 に挙げられている。

2) 本症の形態学的特徴を明らかにする為に、成人男性、成人女性、各患者の身長に相当する年齢の男児及び女兒との比較が、標準化された偏差を用いて行われた (図 1—4, 表 2)。本患者は一様に背が低く、高、長径の身長との比は概して成人男性のそれに近く、幅、周径は比例的にいずれの比較対照よりも大きく、又頭部計測値は成人女性に近い値を示し、身体の均衡が独特な型を有する事が示された。

3) 本症の形態学的特徴の変異性が、標準化された偏差の不偏分散を用いて検討された (表 3)。いずれの比較の場合にも、対照の有する変異よりも、小さい変異を有する測度が多く——統計的に有意でない事が多い——本患者の形態学的相互類似性の強い事が示された。

4) 形態学的類似性を成人男性、成人女性、男児又は女兒のいずれに求め得るかを示す為に PENROSE の shape distance が用いられた (表 4)。本患者は全体として成人女性に最も近く、そして成人男性に最も遠い位置にある事が示された。しかし興味ある事実は、体部比例値 7 項目に基づく shape distance が成人男性で最も小さな値を、女兒に最も大きな値を示した事である。この点で幼若性は排除される。又この事は性差を最も良く表す測度の一つと考えられる腰幅と肩幅の比が成人男性のそれと殆んど同じ値を示すという事と矛盾しない。

5) 本患者が比例的に肩幅が広く、腰幅が狭く、下肢がやゝ短いという事は Klinefelter 症候群患者の狭い肩、広い腰、長い下肢と著しい対照をなし、これら測度の成長機構と X 染色体の異常との間の密接な関連を想像させる。

6) LYON ('61) の仮説に基づく GARTLER ら ('63) の本症候群の成因に対する新しい解釈が考察された。

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