Characteristics of Pulmonary Diffusing Capacity in Japanese —On the Sexual and Ethnic Differences

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Abstract Pulmonary diffusing capacity for CO (D_L), the diffusing capacity of the pulmonary capillary membrane, and pulmonary capillary blood volume were measured for 63 male and female subjects aged 17 to 33 years in both sitting and supine postures. From the relationship of these values to morphological factors, the existence and cause of sexual and ethnic differences in D_L were investigated. The average D_L values for males in both positions were about 35% larger than those for females; even when corrected by body size, such as body surface area or stature, significant sexual difference was found. This difference disappeared when D_L was corrected by difference in alveolar volume. That is, differences between men and women in body size and ratio of lung volume to body size are thought to account for sexual difference in D_L . From comparison with other reports, an ethnic difference in D_L was recognized between Caucasians and Japanese, and its cause is suggested to be the same as cause which accounts for the difference by sex among Japanese.

Keywords Pulmonary diffusing capacity, Japanese, Sex, Posture, Ethnic difference

It is known that pulmonary diffusing capacity for CO (D_L) changes not only during physical exercise but also while at rest, depending on posture and ambient temperature. These changes in D_L occurring within an individual have been attributed solely to changes in pulmonary capillary blood volume (V_c) under a nearly constant diffusing capacity of the pulmonary capillary membrane (D_m) according to observations in research conducted thus far (YASUKOUCHI,

1985a, b, c). However, in the case of measurement of D_L in rest under fixed conditions, the differences in D_L among individuals are thought to be influenced by D_m and V_c , which largely reflect diverse human morphological factors. This may explain why equations to estimate normal values for D_L use age and some anthropometric parameters such as stature, body weight, and body surface area. YASUKOUCHI (1985c) suggests that differences in lung volume between

men and women account partly for sexual difference in change of D_L by thermal stimulation. Thus, to explain what has a physiologically meaningful relation to D_L among morphological factors supports the view that his work is useful for further investigations of individual, sexual, and ethnic differences in D_L .

The purpose of this study is to clarify the relationship of body size or lung volume to the D_L values obtained in sitting and supine postures and to investigate the cause of sexual differences in D_L and in postural change of D_L . It discusses the possible existence and cause of ethnic differences in D_L from the relationships between D_L and morphological factors.

Methods

The subjects in the present study were 63 healthy and young adult males and females (aged 17 to 33) who live in or near Tokyo. They completed a questionnaire based on the adult questionnaire (ATS-DLD-78-A) in the Epidemiology Standard Project (FERRIS, 1978), the results of which were used to screen out those with hematologic, cardiovascular, or chronic pulmonary disease. Of the 63 subjects, eleven males were staff members of a research institute, the remainder being high school students, college students, and housewives. There were seven cigarette smokers out of 29 males and three out of 34 females. They all smoke less than 20 cigarettes per day. The smokers were requested to avoid smoking for at least two hours prior to the test.

After the subject entered a climatic chamber held at 25°C and a relative humidity of 50–60%, he rested in a sitting posture for about 10 minutes. Meanwhile, an investigator chatted with him to reduce any

mental tension that he might have had. Before measurement of D_L , an explanation was given to the subject concerning items requiring his cooperation. Thereafter, two or three practice trials were made without using the test gas. The method used to measure D_L was an 8-s breath-holding method, modified from the method of OGILVIE *et al.* (1957), using a closed system apparatus (Chest) which includes a spirometer and two 15-l bag-in-boxes. The validity of breath-holding time, an 8-s, has been confirmed in the previous study (YASUKOUCHI, 1984). An investigator operated the five-way tap moved in accordance with the changes in breathing phase necessary to measure D_L . The subject only repeated the following sequence under the investigator's instruction: (1) rapid exhalation to near residual volume, (2) rapid inhalation to near total lung capacity, (3) breath-holding, and (4) rapid exhalation to near residual volume. Not only did this further reduce the subject's tension, but it minimized measurement errors arising from differences in operation by the subjects or by mistaken operation of the tap. D_L was determined five times—three with the subject breathing the room-air mixture and two breathing the high- O_2 mixture. The room-air mixture contained 0.3% CO, 0.3% Ne, 21% O_2 , and balance N_2 . The high- O_2 mixture contained 0.3% CO, 0.3% Ne, 15% N_2 , and balance O_2 . Before using the high- O_2 mixture, the subjects breathed pure O_2 for 2 to 3 minutes in order to increase beforehand the alveolar partial pressure of O_2 . After the five measurements of D_L with the subject seated, the subject lay supine on a bed. After a five-minute rest, further five measurements of D_L were made, the same as for the sitting posture. Each posture was maintained for

about 25 minutes during the measurement of D_L .

The D_m and V_c estimates were calculated by the equation $1/D_L = 1/D_m + 1/\theta_{co} \cdot 1/V_c$, given by ROUGHTON and FORSTER (1957). Here, the θ_{co} is the rate of CO reaction with oxyhemoglobin contained in red cells. The value was calculated under the condition of that the ratio of membrane permeability to that of the red blood cell interior (λ) has an infinite value (GEORGES *et al.*, 1978). The gas to be analyzed was taken in 10-ml-volume airtight syringes (Dynatech Precision Sampling, Pressure-Lok Series A-2). After the tests were completed, concentration ratios of inspired and alveolar gas with respect to CO and Ne in the test gas were determined (SMITH and HAMILTON, 1962) using a gas chromatograph (Hitachi, gas chromatograph 163). Also, the oxygen concentration in the alveolar gas was measured by a polarograph electrode (Aika, O_2 analyzer RAS-31).

After all D_L measurements had been made, the subject's stature, body weight, and sitting height were recorded. After rest of a few minutes, vital capacity of 30 female and 17 male subjects was measured in the sitting position at least three times by a rolling seal spirometer (Chest, Chestac 65).

The resulted D_L values are the average of the three trials for each posture, expressed as STPD. If one trial varied by more than 10% of the average of the other two trials, it was excluded. The resulted vital capacity values are the maximal value among trials within 5% difference. Alveolar volume (V_A') was considered to be almost the same as the end-inspiratory alveolar volume obtained by the dilution of Ne during breath-holding. Vital capacity and V_A' were expressed as BTPS.

Results

The subjects' physical characteristics, average values for measurements in both sitting and supine postures, standard deviations, ranges, and the number of individuals are given in Table 1. A result which shows a significant sexual or postural difference by t-test is marked by an asterisk. Although there was no difference in age between the male and female subject groups, all the anthropometric parameters—stature, body weight, sitting height, and body surface area—were significantly larger for males at the level less than 0.5%. Vital capacity as well as V_A' , D_L , D_m , and V_c values for both positions were significantly larger for males at the level less than 0.5%. Further, these sexual differences could not be eliminated even when corrected by body size, i. e., stature, body weight, and body surface area. However, when D_L , D_m , and V_c were corrected by V_A' , the sexual difference disappeared. The only case for which no postural difference was found was the values for both male and female of D_m , or D_m corrected by stature or V_A' ; all others showed a significant difference.

The analysis of covariance for a regression equation of vital capacity on stature shows that the regression coefficients for male and female subjects are the same ($F=1.611$). A significant difference in y-intercepts ($F=9.428$, $P<0.005$) was found. Using the regression coefficient common to male and female groups, the regression equations for each group are as shown in Fig. 1, where the difference in the elevation between the two lines represents 0.51 liters. Calculation, for both postures, of regression equations of V_A' on stature showed the same results as the relationship between vital capacity and

Table 1. Anthropometric parameters and lung function in the sitting and supine subjects.

	Mean	S.D.	Range	N	Postural diff.	Mean	S.D.	Range	N	Postural diff.	Sexual diff.
Age (years)	23.3	4.6	17 — 33	29		21.8	3.8	17 — 33	34		N.S.
Stature (cm)	169.2	6.0	159.6 — 180.7	29		159.2	5.5	144.1 — 168.3	34		***
Body Weight (kg)	61.6	8.3	48.4 — 89.9	29		52.5	6.2	40.8 — 69.4	34		***
Sitting height (cm)	90.7	3.2	85.4 — 96.9	29		85.5	2.7	78.4 — 90.5	34		***
Body surface area (m ²)	1.66	0.12	1.46 — 2.01	29		1.49	0.10	1.24 — 1.75	34		***
Sitting position											
V.C. (l, BTPS)	4.43	0.60	3.52 — 5.44	17		3.43	0.43	2.49 — 4.25	30		***
V.C./ST (l/m)	2.62	0.32	2.15 — 3.25	17		2.15	0.24	1.62 — 2.62	30		***
V _A ' (l, BTPS)	5.29	0.65	3.87 — 6.91	29		4.11	0.56	2.72 — 5.39	34		***
D _L (ml/min/Torr)	30.6	4.4	21.5 — 41.0	29		22.4	3.5	15.6 — 30.7	34		***
D _M (ml/min/Torr)	65.5	14.3	34.1 — 101.6	29		46.2	8.7	30.5 — 65.6	34		***
V _c (ml)	60.5	10.4	38.4 — 85.2	29		43.9	7.8	30.5 — 59.7	34		***
D _L /ST (ml/min/Torr/m)	18.1	2.5	13.1 — 23.0	29		14.0	2.1	10.8 — 18.2	34		***
D _M /ST (ml/min/Torr/m)	38.7	8.3	20.8 — 60.5	29		29.0	5.3	19.8 — 42.1	34		***
V _c /ST (ml/m)	35.8	6.0	22.1 — 48.1	29		27.5	4.6	18.9 — 37.2	34		***
D _L /V _A ' (Kco, ml/min/Torr/l)	5.8	0.8	4.3 — 7.6	29		5.5	0.8	4.2 — 7.4	34		N.S.
D _M /V _A ' (ml/min/Torr/l)	12.4	2.3	8.1 — 17.4	29		11.3	1.9	7.9 — 15.8	34		N.S.
V _c /V _A ' (ml/l)	11.6	2.4	6.6 — 16.6	29		10.8	2.0	7.2 — 16.5	34		N.S.
Supine position											
V _A ' (l, BTPS)	4.88	0.67	3.67 — 6.45	29	*	3.84	0.53	2.52 — 4.75	34	*	***
D _L (ml/min/Torr)	33.5	4.4	24.5 — 44.4	29	*	24.7	3.7	16.0 — 36.2	34	**	***
D _M (ml/min/Torr)	63.0	11.7	44.1 — 87.2	29	N.S.	46.9	8.2	33.9 — 71.5	34	N.S.	***
V _c (ml)	73.8	11.7	53.1 — 97.1	29	***	53.5	9.9	29.1 — 74.2	34	***	***
D _L /ST (ml/min/Torr/m)	19.8	2.3	15.0 — 24.6	29	**	15.5	2.1	11.1 — 21.5	34	**	***
D _M /ST (ml/min/Torr/m)	37.2	6.4	26.7 — 48.6	29	N.S.	29.5	5.0	20.6 — 42.5	34	N.S.	***
V _c /ST (ml/m)	43.6	6.4	32.9 — 55.4	29	***	33.6	5.7	20.2 — 44.8	34	***	***
D _L /V _A ' (ml/min/Torr/l)	6.9	0.7	5.8 — 9.4	29	***	6.5	1.0	5.1 — 10.5	34	***	N.S.
D _M /V _A ' (ml/min/Torr/l)	12.9	1.4	10.6 — 15.4	29	N.S.	12.3	2.0	9.5 — 19.5	34	N.S.	N.S.
V _c /V _A ' (ml/l)	15.4	3.1	11.1 — 22.9	29	***	14.1	2.9	9.2 — 22.3	34	***	N.S.

Body surface area was calculated from the equation of FUJIMOTO *et al.* (1968).

Abbreviations: V.C., vital capacity; V_A', end-inspiratory alveolar volume at the measurement of pulmonary diffusing capacity; ST, stature; D_L, pulmonary diffusing capacity; D_M, diffusing capacity of the pulmonary capillary membrane; V_c, pulmonary capillary blood volume; *, P<0.05; **, P<0.01; ***, P<0.001.

Fig. 1. Vital capacity against stature for males and females.

stature. Concerning the relationship between V_A' and stature, the differences in the elevation between equations having a regression coefficient common to male and female groups was 0.55 liters for the sitting and 0.57 liters for the supine position. These results show that stature being equal, the lung volume in males is clearly larger than in females in both postures.

Those anthropometric parameters, V_A' , and age that showed a significant simple correlation with D_L , D_m , or V_c for both groups and both postures are given in Table 2 together with the results of stepwise multiple regression analyses on these parameters. For sitting males, stature did not exhibit a significant simple correlation with D_L , D_m , or V_c , although it was significant with respect to all three parameters in the supine position. In the case of females, stature and body weight showed a significant correlation with D_L and V_c for

both postures. D_m in males showed a negative correlation with age for both postures, while V_c was independent of age. This shows that the effects of age on D_L seen in males is due to effects of age on D_m . For females, aging effects did not appear for any parameter. Stepwise multiple regression analyses of D_L , D_m , and V_c on age, V_A' , and anthropometric parameters were performed. Those variables showing at least the 5% significance level were, in the estimation of both D_L and D_m in both postures, age and V_A' for males and only V_A' for females. Further, the significantly correlated parameters with V_c for males and females were body weight in the sitting position, and body surface area in the supine position. Thus, among the anthropometric parameters and V_A' ; variables common to both male and female groups are V_A' in the estimation of D_m , and body weight or body surface area in the estimation of V_c .

Table 2. Correlation and stepwise multiple regression analysis of D_L , D_M , and V_c on anthropometric parameters in the sitting and supine subjects.

Independent variables and simple correlation coefficient					Step No.	Variable entered	R	F to enter
MALE								
Sitting position								
D_L	Age	V_A'			1	V_A'	.481**	8.115
	-.452*	.481**			2	Age	.625**	6.785
D_M	Age	V_A'			1	V_A'	.531**	10.613
	-.530**	.531**			2	Age	.710***	11.632
V_c	BW	BSA			1	BW	.555**	12.043
	.555**	.519**						
Supine position								
D_L	Age	ST	BW	BSA	V_A'	1	V_A'	.569**
	-.517**	.500**	.391*	.474**	.569**	2	Age	.728***
D_M	Age	ST	V_A'			1	V_A'	.580***
	-.517**	.402*	.580***			2	Age	.736***
V_c	ST	BW	BSA			1	BSA	.531**
	.392*	.509**	.531**					10.626
FEMALE								
Sitting position								
D_L	ST	BW	BSA	V_A'	1	V_A'	.592***	17.291
	.342*	.550***	.552***	.592***				
D_M	BW	BSA	V_A'		1	V_A'	.536**	12.925
	.390*	.375*	.536**					
V_c	ST	BW	BSA	V_A'	1	BW	.624***	20.418
	.340*	.624***	.574***	.431*				
Supine position								
D_L	ST	BW	BSA	V_A'	1	V_A'	.480**	9.587
	.389*	.462**	.468**	.480**				
D_M	V_A'				1	V_A'	.345*	4.317
	.345*							
V_c	ST	BW	BSA	V_A'	1	BSA	.592***	17.282
	.490**	.583***	.592***	.493**				

Abbreviations: BW, body weight; BSA, body surface area; R, multiple correlation coefficient; others are the same as those in Table 1.

From the fact that D_m and V_c are accounted for by different variables, and the fact that the correlation coefficients between D_m and V_c are small both for male and female groups (male: sitting $r = -.074$, supine $r = .157$; female: sitting $r = .320$, supine $r = .283$), it can be seen that D_m and V_c are independent from each other. Thus, it can be considered that D_L both in males and females is comprised of a component (D_m) determined mainly by alveolar volume and a

component (V_c) determined mainly by overall body size.

Table 3 shows the results of a multiple regression analysis of D_L on D_m and V_c both in males and females. Because of their independent relation, D_m and V_c showed an extremely high partial correlation with D_L . Further, the relative contributions of D_m and V_c to D_L , calculated from the standardized partial regression coefficients, were approximately equal.

Table 3. Multiple regression analysis of D_L on D_M and V_c in the sitting and supine subjects.

	SPCC	RC (%)	PCC.	R
MALE				
Sitting position				
V_c	0.712	50.6	.926***	
D_M	0.694	49.4	.922***	.957***
Supine position				
D_M	0.731	56.8	.973***	
V_c	0.555	43.2	.955***	.985***
FEMALE				
Sitting position				
V_c	0.609	50.2	.983***	
D_M	0.604	49.8	.983***	.994***
Supine position				
D_M	0.627	50.6	.979***	
V_c	0.611	49.4	.978***	.992***

Abbreviations: SPCC, Standardized partial correlation coefficient; RC, relative contribution of D_M and V_c in the estimation of D_L by multiple regression; PCC, partial correlation coefficient; R, multiple correlation coefficient; others are the same as those in Table 1.

Discussion

In order to obtain more precisely the D_L value in rest for each individual, D_L was determined three times in succession and the average was analyzed here. The ratios of the difference between the largest and the smallest values to the smallest value of the two or three values used to compute the average were $3.8 \pm 2.2\%$ and $5.3 \pm 3.0\%$ for sitting and supine postures, respectively, for males and $5.1 \pm 3.2\%$ and $5.0 \pm 3.3\%$ for sitting and supine postures, respectively, for females (average values $\pm$ standard deviation); these percentages indicate the stability of the repeated determinations. Also, concerning the D_L value in rest for the same person, the reproducibility of measurements taken on different days was confirmed in the previous study (YASUKOUCHI, 1985b), and the present values are considered to be

similar to the true value in rest for each individual.

Postural differences in D_L depended only on changes in V_c , which agreed with the results in the previous studies (YASUKOUCHI, 1985a, b, c) on changes in D_L within an individual. However, as for changes in D_L among individuals, the relative contributions of V_c and D_M to D_L were approximately equal (Table 3). This shows a result different from that obtained for changes in D_L within an individual.

A clear sexual difference in D_L was seen: values for males were larger by 36.6% in sitting posture and by 35.6% in supine posture than those for females. Such difference between males and females is still significant below the 0.5% level even when D_L is corrected by body size by taking into account such factors as stature. The variation cannot be explained only by difference

between sexes in body size. By contrast, from the fact that there was no sexual difference in diffusion constant (D_L/V_A'), which is related to factor 'K' (KROGH, 1915) by a pressure conversion, and from the fact that a sexual difference was found in the elevations of regression lines for indices of lung volume to stature, the sex difference in D_L can be considered to be influenced also by differences in lung volume for the same stature. Results from multiple regression analysis, common to both sexes, indicate that the two components, D_m and V_c , which determine D_L can be accounted for to some extent by V_A' and body weight or body surface area (Table 2), and that D_m and V_c contribute equally to D_L (Table 3). Therefore, it seems that the absolute values of lung volume and body size, as well as the sexual difference in their ratio, influence the variation in D_L by sex. Otherwise, from the fact that no sexual difference was found regarding diffusion constant, the variation in D_L may also be explained simply by differences in lung volume.

As noted previously, the postural variation in D_L depended only on changes in V_c . In the upright position, V_c is regulated by the level of pulmonary arterio-venous pressure (WEST *et al.*, 1964) as shown in Fig. 2; in the supine posture, since the whole lung is filled with blood, it can be seen that V_c becomes larger than that in the sitting posture. Assuming that pulmonary arterio-venous pressure is nearly constant and not dependent on sex and physical stature (BRAUNWALD *et al.*, 1961; TAJIMI *et al.*, 1983), it can be thought from this figure that postural variation in V_c becomes greater with increasing vertical height of the lung. Figure 3 shows the relationship of V_c to stature which is thought to reflect

Fig. 2. Schematic figure of the lung in the upright position for the male (larger one) and the female (smaller one). This shows the relative heights and volumes of perfusion area. $\bar{P}_{pa}$, mean pulmonary artery pressure; P_v , pulmonary venous pressure.

Fig. 3. Pulmonary capillary blood volume (V_c) against stature in the sitting (A) and supine (B) positions for males and females.

the vertical height of the lung; A for sitting and B for supine postures. In the sitting posture, the significant correlation was found only for females. Since V_c in sitting depends on the level of pulmonary arterio-venous pressure, in a group with relatively high vertical lung height as in males, variations in V_c due to differences in vertical lung height are difficult to produce compared with the female (Fig. 2). However, since the whole lung is filled with blood in the supine posture, the significant correlation was found for males also (Fig. 3B). Pooled data for both sexes shows a tendency of a stronger influence of stature in supine posture than in the case of sitting posture. Thus, in the overall data for both groups, postural change in V_c shows a significant positive correlation with stature ($r=.402$, $P>0.005$). As for diffusion constant depending on the uniformity of the distribution of ventilation and perfusion in the lung, the relation of diffusion constant to stature was similar to the relation of V_c to stature in the sitting position for each sex, but the dependency on stature disappeared in the supine position because blood is distributed equally throughout the lung regardless of stature. Thus, the relation of postural change in diffusion constant (ΔK_{co}) to stature is significant only for females (Fig. 4). For males, the relatively high level of ΔK_{co} seems to be maintained.

Normal values of D_L are most often estimated from age and stature due to the complexity of the measurement. However, as seen for males in sitting posture in the present study, D_L does not necessarily exhibit a good correlation with stature. By contrast, the physiological significance of V_A' with respect to D_L can be seen from the fact that sexual differences in D_L , D_m , and V_c

Fig. 4. Postural change in diffusion constant (K_{co} , or D_L/V_A') against stature for males and females.

disappear when the values are corrected by V_A' . That is, the sexual difference in D_L is not simply due to the differences in overall body size between male and female; rather, the sexual difference in the ratio of lung volume to overall body size can be considered one of the main causes. If the relationship between lung volume and stature differs among races, therefore, the same phenomenon seen in the sexual difference in D_L would exist among races.

Concerning ethnic differences in lung volume, there are some reports indicating that the value for Caucasians is larger than that for Negroes (PAUL *et al.*, 1960; DAMON, 1966; LAPP *et al.*, 1974). Using the data on Europeans and Africans collected in Rhodesia by PAUL *et al.* (1960), ROSSITER and WEILL (1974), having corrected width, depth, and height of chest measurements by the ratio of statures for the two groups, still found a difference of 13.2% in lung volume calculated from the data. They have also implied that there is an ethnic difference in D_L . There are reports suggesting a similar trend between Europeans and Asians (DUGDALE *et al.*, 1971; CHUAN and CHIA, 1969; AYUDHYA *et al.*, 1980). From a comparison of the comparable groups of Chinese and

Europeans, CHUAN and CHIA (1969) indicates that difference in total lung capacity between the two ethnic groups can be explained by difference in vital capacity. According to ABRAMOWITZ *et al.* (1965), vital capacity per stature is 28.0 and 25.3 ml/cm for Caucasians and Negroes, respectively, and this difference is significant at the 0.1% level. The value for males in the present study was 26.2 ml/cm which was similar to that of Negroes than Caucasians. Concerning the value of D_L per stature, the result

of McGRATH and THOMSON (1959) was 20.5 ml/min/Torr/m for fifteen males aged 17 to 32, the value larger than that of 18.1 ml/min/Torr/m found in the present study. These reports indicate at least the possibility that morphological differences, including differences in lung volume between Japanese and Caucasians, give rise to some variation in D_L .

Table 4-A, B show the results reported by various authors of normal D_L values for sitting posture by the breath-holding method.

Table 4-A. D_L and diffusion constant (Kco) in the male Japanese and other ethnic groups.

Author	Nation or ethnic group	Mean	Age ±S.D.	(range)	N	Stature	Body weight	D_L	Kco
EDWARDS <i>et al.</i> * (1972)	European	21.8		(20-24)	6	181	70.7	33.5	4.6
	East Indian	25.8		(23-29)	12	167	60.0	30.0	5.3
	West African in Jamaica	25.6		(22-29)	12	174	66.8	32.5	5.5
ROSSITER and WEILL* (1974)	White	40.9		(22-79)	97	176.3		34.8	
	Black in New Orleans, U.S.A.	34.4		(21-70)	147	177.9		31.4	
COTES <i>et al.</i> * (1965)	Indian	23			17			31.5	6.1
	European (Welsh) in India	23			30			32.3	5.6
BILLIET <i>et al.</i> * (1963)	Belgium (Louvain)			(20-75)	57			37.0	5.9
ENGLERT* (1964)	Belgium (Bruxelles)			(18-79)	70			33.8	5.5
CRAPO <i>et al.</i> * (1981)	U.S.A. (Salt Lake City)	48.5	20	(15-91)	123	175	80	38.9	6.3
BRADLEY <i>et al.</i> * (1979)	White in U.K.	39.8	14.8	(15-65)	52	176.7		33.5	5.7
TECULESCU <i>et al.</i> * (1970)	Romania	41.0	13.7		47	169.4		37.2	
COTES <i>et al.</i> (1973)	New Guinean (coastal people)	24.5		(17-32)	27	165	58.3	26.7	5.4
AYUDHYA <i>et al.</i> * (1980)	Thailand			(16-72)	60			27.2	
KANAGAMI <i>et al.</i> (1963)	Japanese				17			29.8	
NAKAMURA <i>et al.</i> (1963)	Japanese				7			30.9	
NISHIDA <i>et al.</i> (1976)	Japanese			(20-29)	34	166	60.3	30.5	5.8
Present study	Japanese	23.3	4.6	(17-33)	29	169.2	61.6	30.6	5.8

* shows that the data have been adjusted to the mean values of age and stature (23 yr and 169 cm, respectively) in the present study.

Table 4-B. D_L and diffusion constant (Kco) in the female Japanese and other ethnic groups.

Author	Nation or ethnic group	Mean	Age $\pm$ S.D.	(range)	N	Stature	Body weight	D_L	Kco
BILLIET <i>et al.</i> * (1963)	Belgium (Louvain)			(20-68)	41			27.6	6.2
ENGLERT* (1964)	Belgium (Bruxelles)			(18-79)	21			25.2	5.6
CRAPO <i>et al.</i> * (1981)	U.S.A. (Salt Lake City)	49	20	(17-84)	122	161	66	29.2	6.0
HALL <i>et al.</i> * (1979)	British women			(27-74)	113			28.9	
BRADLEY <i>et al.</i> * (1979)	White in U.K.	37.7	12.7	(15-59)	44	165.0		25.6	5.7
COTES <i>et al.</i> * (1973)	New Guinean (coastal people)	22.0		(17-31)	26	156	52.4	22.8	6.0
AYUDHYA <i>et al.</i> * (1980)	Thailand			(16-72)	40			19.4	
NISHIDA <i>et al.</i> (1976)	Japanese			(20-29)	22	153	49.6	23.4	6.1
Present study	Japanese	21.8	3.8	(17-33)	34	159.2	52.5	22.4	5.5

* shows that the data have been adjusted to the mean values of age and stature (22 yr and 159 cm, respectively) in the present study.

Names of ethnic groups in the table are those given in these report or, when not given, the name of the country of the author's affiliated institution. Those values of D_L and diffusion constant (Kco) in reports that could be corrected by age, stature, body weight, or body surface area were adjusted to the average values for each sex in the present study and these reports are marked with an asterisk. The present D_L values for males and females agree well with other Japanese data and can be regarded as normal values in the Japanese. For males, an average value for New Guineans, Thailanders and Japanese, weighted for the number of individuals studied, is 28.7, that for Negroes 31.5, and Caucasians (or those so considered) 35.9 ml/min/Torr. D_L in the table for Japanese are higher than those of New Guineans and Thailanders and are, rather, similar to the value for Negroes. The D_L result obtained here is 85% of that of the

average Caucasian value. By contrast, the average values of diffusion constant (Kco) for males in the present study and Caucasians are, respectively, 5.8 and 5.9 ml/min/Torr/l, which show good agreement with each other. For females, the average D_L value for Asians is 21.7 and that for Caucasians 28.2 ml/min/Torr. Although corrected by a shorter stature than males, the value for Caucasians is similar to that for Asian males. In the present study, D_L was 79% of the average for Caucasians. However, there seems to be no ethnic difference in diffusion constant, the same result as for males. D_L values for Japanese of both sexes, even when corrected by age and body size, are lower than those for Caucasians, showing existence of an ethnic difference. On the other hand, since the difference in diffusion constant is nearly disappeared, it seems that the same cause of sexual difference in D_L found in the present study

influence ethnic differences.

Acknowledgement

The author wishes to express his appreciation to Prof. M. SATO, Dept. of Ergonomics, Kyushu University of Design Sciences, for his encouragement and helpful suggestions. The author also wishes to thank Dr. NAKADATE, Dept. of Experimental Toxicology, National Institute of Industrial Health, for his constant support in the present investigation. The appreciation is also expressed to Mr. MATSUI, Dept. of Industrial Epidemiology and to Mr. OKUNO, Dept. of Human Environmental Engineering, National Institute of Industrial Health, for their helpful advice in operating computer.

抄 録

日本人の肺拡散能の特徴—性差, 人種差について

安 河 内 朗

年齢17歳から33歳までの63名の男女について, 椅座と仰臥の両姿勢における肺拡散能 (D_L), 膜拡散能 (D_M), および肺毛細管血液量 (V_c) が求められた。これらの測定値と形態的要素との関係から, D_L とその姿勢変化の性差が調べられ, さらに D_L の人種差が検討された。男子の D_L は平均値においていずれの姿勢でも女子より約35%大きく, 身長や体表面積のような体格の差で補正してもなお有意な性差が認められた。これらの差は, 肺胞容量で補正したときはじめて消失した。すなわち, 男女間の全身的な大きさ, およびこれと肺容量間の相対比の違いによって D_L に性差が生じるものと考えられた。

D_L の姿勢差は男女に共通してみられ, いずれも V_c の姿勢差に依存することが示された。 V_c の姿勢差は, 身長との関係から男女いずれも直立した肺の垂直方向の高さの高いものほど大きくなることが示された。単位肺胞容量当たり D_L の姿勢差と身長との関係では, 身長の低い集団である女子のみににおいて有意な関係が認められた。

他文献との比較の結果, 日本人とコーカソイドとの

間では D_L を体格の違いで補正してもなおコーカソイドは高い値を示したが, D_L を肺胞容量で補正すると人種間の差は認められなかった。したがって日本人とコーカソイド間にみられた人種差の主な原因は, 日本人の D_L の性差にみられた原因に類似するものと考えられた。

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