

BODY SIZE DATA OF SRI LANKAN WORKERS AND COMPARISON WITH OTHER POPULATIONS IN THE WORLD: ITS IMPACT ON THE USE OF IMPORTED GOODS

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Abstract : A national anthropometric survey of Sri Lankan workers has provided upto-date information on the body sizes of both males and females. This data (which was lacking in Sri Lanka) can be of great benefit for designers and importers of goods for Sri Lankans. Simple and anthropologically spread techniques have been used to collect the data. Comparisons of body sizes between developing countries (including Sri Lanka) with those of developed countries revealed wide variations which have been responsible in the incompatibility in the use of imported goods. Anthropometric data of homogenous populations in different countries are not usually available and more so in developing countries. It is emphasized that such data be developed in all countries or in every ethnic group or on a regional basis. The designers, manufacturers and importers of goods should have access to this data. It is suggested that the techniques and methods described in this paper can be used by developing countries lacking similar data.

1. Introduction

Sri Lanka imports machinery, vehicles and various other items and articles manufactured in foreign countries. These imported items which are manufactured to fit people in those countries, in many instances, cannot be used safely, efficiently and comfortably by the local population. Many problems of inadequacies in design have been experienced by Sri Lankans, either in using imported and even locally produced machines, which have been made disregarding the body sizes of the users. In order to design machines, articles, garments and work places to match a population, an important requirement for the designer is the information regarding body dimensions of the people. There are records of anthropometry of Sri Lankans, but they refer to specific age groups or populations viz. University students³ or to school children⁵ and more recent data collected with the purpose of ascertaining the physical differentiation of the main races in Sri Lanka.^{1,3} As the required body measurements of the homogenous population of Sri Lanka are not available, a survey was planned and carried out on a national sample of the population of workers, both male and female. The techniques and procedures described in this paper can be of benefit to those planning such surveys.

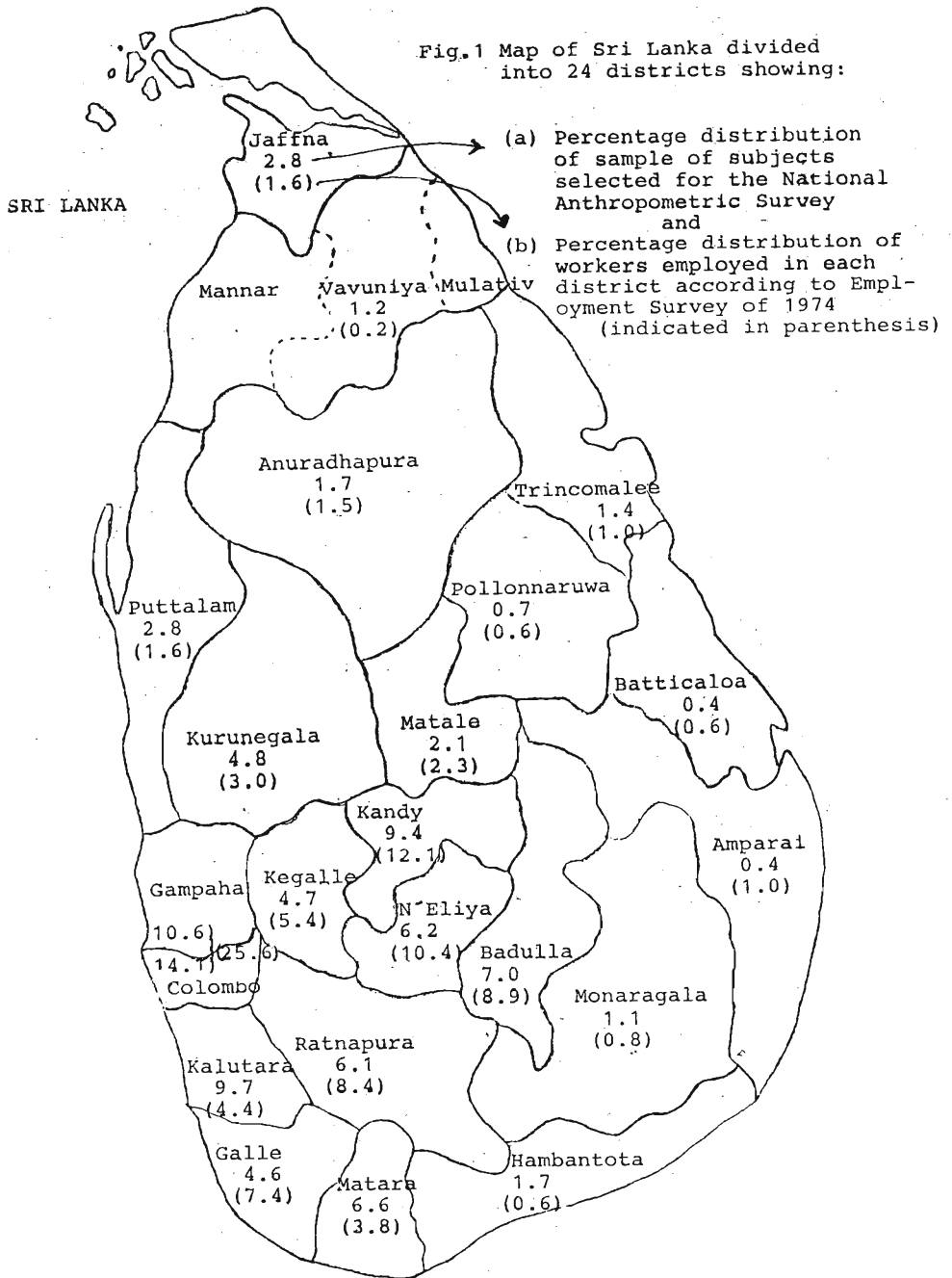
Sri Lanka is a tropical Asian country with a geographical area of approximately 65,000 square kilometers and a population of about 16 million people of whom about 30% consists of the working population. Workers were taken as subjects for the body size survey as it was easy to reach them, for measuring convenience of random sampling and they represented a homogenous population. Other reasons are that the majority of imported goods and machines are used by workers. In Industrially Developing Countries (IDC) including Sri Lanka, the unavailability of body size data as well as unawareness of the importance of ergonomics principles are the main reasons why machines and goods are not manufactured or adapted to suit the user population. In this paper anthropometric data of Sri Lankans and other IDC are compared with data of Industrialized Countries (IC) to show the variability in body sizes that exist. The design incompatibility in goods seems to be an important aspect of the problems involved in the transfer of technology from developed to developing countries.

2. Methods and Procedures

The national anthropometric survey of workers in Sri Lanka was carried out during a period of 16 months in 1981/82. The measurements were taken by three trained investigators. A pilot anthropometric survey lasting for three weeks was conducted on 100 fibre mill workers which provided the investigators with adequate experience in carrying out body measurements accurately and speedily.

A total of 90 body measurements, which were chosen to cover anthropometric informations for designers^{2,8} were taken. The total number of subjects was 724 between the ages of 21 and 51 years, of which 438 (60.5%) were males with mean weight 51 kg, (S.D. 8.3 kg), and 286 (39.5%) were females with a mean weight 43 kg, (S.D. 6.5 kg). This sample included workers from all 24 districts from the 7 provinces of Sri Lanka, (Figure 1). The number of subjects from each district was selected on a proportional basis in accordance with the employment survey statistics of 1974.⁷ The five main races which represented the national sample consisted of 581 (80%) Sinhalese, 78 (11%) Indian Tamils, 53 (7.5%) Ceylon Tamils, 9 (1%) Moors and 3 (0.5%) Burghers. Members of the main religious groups, communities and armed forces and also veddhas (a jungle tribe) have been represented in the sample. The subjects from 80 work establishments and employed in various categories of work were selected at random. Except for the age, sex, race and number of subjects from each district, there was no discrimination of the selection of subjects. Sick and disabled persons were excluded.

Simple but accurate measuring instruments were used considering the requirements of easy transportation, reliability of results, durability and



speed of operation and use. The main instrument, Harpenden anthropometer was used to take 50% of the measurements (linear measurements). The circumferences were measured using a canvas flexible measuring tape and for face and head measurements calipers were used. Few measurements were taken with a steel tape. An adjustable flat seat was used to take seated measurements.

Out of the total of 90 body measurements only 85 were actually taken. The other measurements were derived, (e.g. measurement nasion to menton was derived by subtracting measurement nasion to vertex from measurement menton to vertex). The 90 measurements included the weight, 28 standing measurements, 15 sitting, 12 circumference, 25 head, 4 hand and 5 foot.

The measurements were carried out at the respective work places. Male subjects wore briefs, females wore skirt and blouse of thin material and all were measured without footwear. Two members of the team alternately measured and recorded to reduce boredom and fatigue. The data were recorded on specially designed forms. The recorder also verbally confirmed each measurement before entering it in the form.

The measurements always were carried out on the left side of the subject. The posture adopted by the subject during measurements and the anatomical points of the measurements were as indicated in Figures 2a to 2h. The hand, feet and head measurements (Figures 2f to 2h) were taken while the subject adopted a standing posture.

When using the anthropometer and the calipers, care was taken that only light pressure was applied (by the datum probes) at the part of body contact, in order not to indent the flesh. Tape measurements were taken with the tape tension such that the flesh was not significantly indented.

All data were scrutinised for omission and obvious errors. Where errors were apparent, such values were deleted. The checked data were subjected to statistical analyses.

3. Results and Discussion

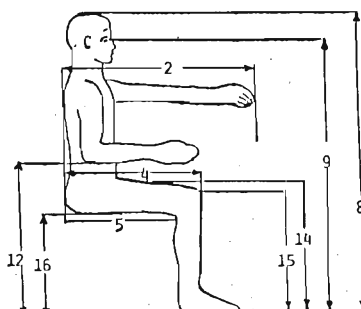
3.1 Data of Sri Lankan Workers

The anthropometric data of Sri Lankan workers have been statistically summarised for each of 90 measurements, with mean, standard deviation, number of subjects and 5th and 95th percentile values for both males and females, (Figures 2a to 2h). The results of weights are given below. (The results for males appear above and females below).

SITTING MEASUREMENTS

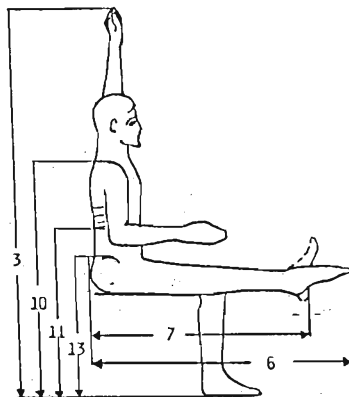
No	Measurements	Mean (mm)	Standard deviation (mm)	Number of subjects	5th percentile (mm)	95th percentile (mm)
2	Horizontal functional reach	780.78	43.91	436	712	854
3	Buttock-Knee Length	324.49	75.27	287	663	790
4	Buttock to back of knee	356.36	32.27	436	611	620
5	Sitting height	534.22	29.49	288	487	572
6	Eye height	459.19	30.55	436	416	507
7	Elbow rest height	445.67	35.41	288	400	494
8	Thigh clearance height	1213.68	56.63	434	1130	1296
9	Knee height	1123.15	44.39	288	1055	1190
10	Elbow rest height	1022.69	45.98	287	940	1090
11	Thigh clearance height	578.39	51.81	436	509	663
12	Knee height	514.42	39.46	287	470	600
13	Stool or seat height	500.57	25.44	435	460	548
14	Stool or seat height	436.42	23.99	288	424	503
15	Stool or seat height	456.32	28.09	431	410	502
16	Stool or seat height	422.10	26.89	284	374	464
17	Stool or seat height	380.14	29.05	414	338	423
18	Stool or seat height	349.31	24.16	285	316	391

Figure 2 (a)



No	Measurements	Mean (mm)	Standard deviation (mm)	Number of subjects	5th percentile (mm)	95th percentile (mm)
3	Vertical functional reach	1640.07	75.85	435	1514	1756
4	Buttock to toe length	1496.56	68.65	286	1386	1615
5	Buttock to heel length	1099.50	71.44	433	1002	1202
6	Shoulder height	1033.35	78.78	286	947	1127
7	Shoulder height	988.50	61.90	436	904	1070
8	Shoulder height	926.25	63.57	287	843	1009
9	Lowest rib height	949.34	50.61	434	876	1025
10	Lowest rib height	873.17	44.96	288	811	940
11	Upper hip bone height	644.76	44.63	435	585	715
12	Upper hip bone height	607.16	36.55	288	550	669
13	Upper hip bone height	541.95	42.52	436	485	619
14	Upper hip bone height	510.32	36.32	287	457	571

Figure 2 (b)



STANDING MEASUREMENTS

No	Measurements	Mean (mm)	Standard deviation (mm)	Number of subjects	5th percentile (mm)	95th percentile (mm)
17	Stature	1639.01	63.51	435	1536	1746
18	Kaxton height	1522.77	58.77	288	1426	1617
19	Eye height	1439.50	59.66	288	1340	1539
20	Subnasala height	1435.31	62.19	432	1329	1543
21	Manton height	1418.89	58.87	288	1323	1520
22	Tragion height	1323.46	59.32	287	1232	1424
23	Elbow height	1396.68	57.69	288	1304	1490
31	Chest depth	1014.04	70.04	436	929	1106
36	Elbow wrist length	941.45	62.11	286	873	1016
39	Forward reach	170.60	19.67	436	146	204
39	Forward reach	161.53	19.40	288	126	193
39	Forward reach	276.31	34.84	436	247	302
39	Forward reach	251.91	33.88	288	225	276
39	Forward reach	817.02	59.83	288	747	888
39	Forward reach	757.37	45.40	288	692	822
39	Forward reach	391.68	25.57	436	350	430
39	Forward reach	355.77	24.86	285	320	395

Figure 2 (c)

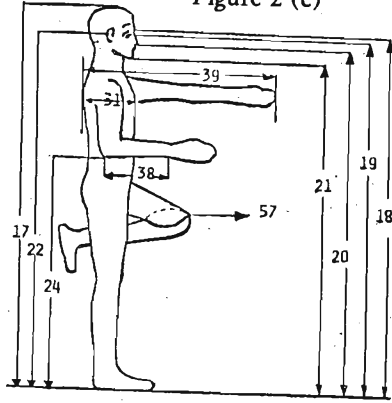
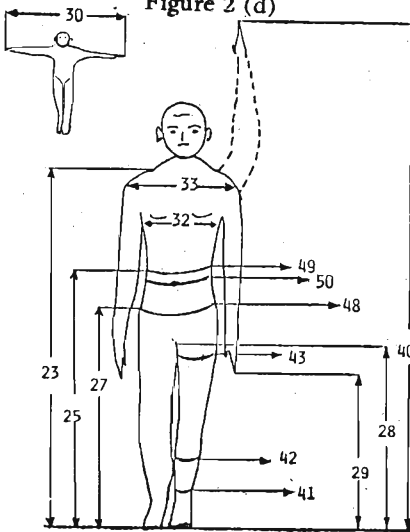
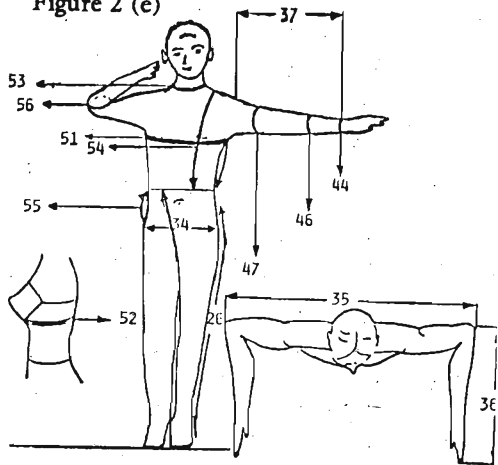


Figure 2 (d)



No	Measurements	Mean (mm)	Standard deviation (mm)	Number of subjects	5th percentile (mm)	95th percentile (mm)
23	Shoulder height	1377.09	59.24	435	1280	1473
25	Waist height	1272.61	53.69	287	1194	1360
27	Hip height	1068.24	64.35	435	975	1160
27	Hip height	1012.79	57.05	288	931	1094
28	Crotch height	920.71	75.94	286	805	1062
28	Crotch height	775.32	48.91	433	707	841
29	Finger tip height	276.74	60.90	186	690	845
30	Span	571.28	45.11	288	554	609
30	Span	1690.56	88.64	435	1506	1816
32	Chest breadth	1544.65	98.93	288	1407	1678
33	Biacromial breadth	749.35	25.80	288	716	782
33	Biacromial breadth	224.77	19.08	436	199	232
33	Biacromial breadth	308.29	23.40	434	251	302
33	Biacromial breadth	331.40	18.46	288	300	361
40	Upward reach	2083.74	115.19	435	1947	2236
41	Ankle circumference	1912.78	110.59	288	1775	2051
42	Calf	196.01	14.84	432	165	229
42	Calf	102.18	11.83	288	85	129
43	Ingh	306.14	27.40	433	265	350
43	Ingh	280.48	22.80	286	252	325
43	Ingh	459.24	46.54	434	395	545
48	Buttock	456.97	46.98	234	390	540
49	Waist	823.25	56.55	432	740	930
49	Waist	832.92	53.97	287	750	925
49	Waist	688.63	68.16	436	605	780
49	Waist	633.44	61.24	288	554	700
50	Abdomen	717.42	70.38	436	630	855
50	Abdomen	727.16	71.76	288	620	860

Figure 2 (e)

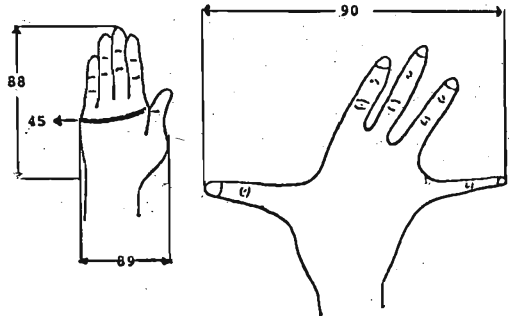


No	Measurements	Mean (mm)	Standard deviation (mm)	Number of subjects	5th percentile (mm)	95th percentile (mm)
26	Outside leg length	1053.60	74.14	258	970	1140
34	Hip breadth	250.36	17.74	436	224	280
34	Hip breadth	246.42	22.22	285	212	281
35	Inter elbow span	861.12	51.29	435	782	940
35	Inter elbow span	793.81	105.98	288	718	868
36	Elbow-fingertip length	450.37	34.26	435	414	492
37	Acromial wrist length	410.32	29.32	288	378	449
37	Acromial wrist length	632.15	57.22	436	406	573
42	Wrist circumference	495.91	29.71	288	450	542
42	Wrist circumference	354.32	9.79	435	340	370
46	Fore arm	330.66	8.65	297	325	350
46	Fore arm	233.07	20.62	435	205	265
47	Upper arm	294.58	15.78	288	280	310
47	Upper arm	242.55	24.87	435	205	290
51	Chest	224.11	27.09	288	190	260
51	Chest	805.80	55.03	436	725	915
52	Under bust	808.11	58.35	288	720	905
53	Neck	724.30	62.68	178	670	1060
53	Neck	341.62	22.28	436	310	360
54	Waist to waist over shoulder	294.86	19.67	288	265	330
54	Waist to waist over shoulder	162.89	43.81	435	680	825
54	Waist to waist over shoulder	680.26	45.63	284	650	750
55	Crotch length	736.02	66.99	410	650	840
56	Elbow fully bent circumference	298.34	27.58	432	260	340
56	Elbow fully bent circumference	260.26	21.32	287	230	295

HAND AND FOOT MEASUREMENTS

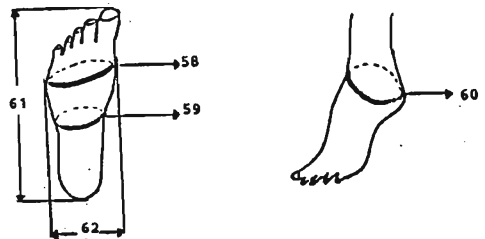
No	Measurements	Mean (mm)	Standard deviation (mm)	Number of subjects	5th percentile (mm)	95th percentile (mm)
15	Hand girth	196.19	16.75	260	175	220
		176.57	13.21	182	160	190
88	Hand Length	179.38	12.03	435	165	195
		166.59	14.02	287	150	182
89	Hand breadth	99.50	6.53	435	90	110
		89.69	5.59	287	80	99
90	Finger span	249.64	15.19	435	185	232
		184.33	15.82	286	160	210

Figure 2 (f)



No	Measurements	Mean (mm)	Standard deviation (mm)	Number of subjects	5th percentile (mm)	95th percentile (mm)
58	Ball of foot circumference	228.80	16.42	433	206	250
		206.39	13.41	288	185	230
59	Instep sole circumference	235.95	15.42	434	215	260
		210.73	14.27	288	190	235
60	Heel instep circumference	319.60	17.96	434	290	345
		289.05	16.47	288	265	315
61	Foot length	252.82	17.43	434	230	280
		236.41	13.15	288	210	255
62	Foot breadth	105.76	10.53	435	90	120
		95.70	12.08	288	80	110

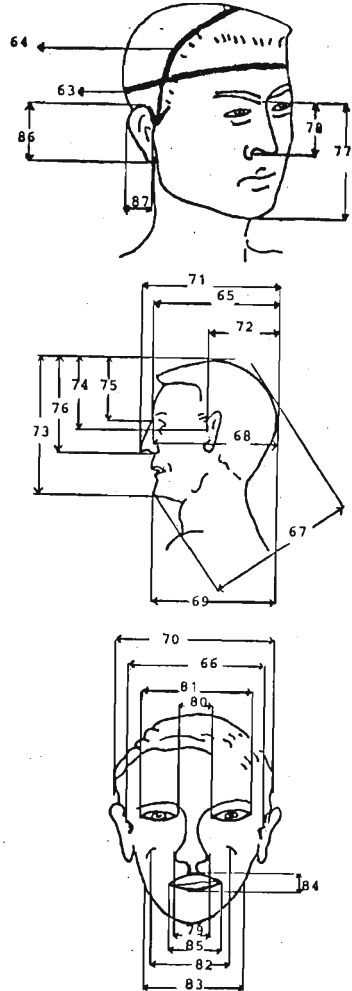
Figure 2 (g)



HEAD AND FACE MEASUREMENTS

Figure 2 (h)

No	Measurements	Mean (mm)	Standard deviation (mm)	Number of subjects	5th percentile (mm)	95th percentile (mm)
63	Head circumference	542.91	18.42	436	515	570
		523.51	14.61	288	500	550
64	Bitrignon coronal arc	343.21	23.68	436	320	370
		327.46	23.50	288	300	355
77	Nasion to menton	119.78	17.53	431	97	144
		113.37	16.10	287	89	135
78	Nose length	51.95	5.04	435	44	59
		49.57	5.56	288	42	57
86	Ear length	59.09	4.90	433	52	67
		55.35	5.38	286	47	62
87	Ear breadth	29.74	3.16	433	25	34
		27.68	3.79	286	23	32
85	Head length	177.50	12.06	434	156	194
		171.25	20.43	288	149	191
83	Max head diagonal from menton	238.87	10.37	436	222	253
		227.33	14.79	285	214	241
80	Nasion to back of head	177.52	12.14	434	160	196
		170.53	12.88	288	150	191
59	Menton to back of head	196.40	16.56	434	173	224
		186.18	15.69	288	160	211
71	Nose tip to back of head	207.52	16.02	434	188	226
		198.78	12.68	289	180	219
72	Trignon to back of head	97.14	13.91	431	77	118
		94.21	13.41	286	74	117
73	Menton to vertex	202.72	28.76	432	169	234
		193.38	20.31	287	163	218
74	Trignon to vertex	133.78	21.52	431	113	153
		127.14	13.99	288	106	146
75	Nasion to vertex	85.72	20.41	432	59	110
		84.25	17.09	288	56	107
76	Subnasale to vertex	136.81	22.75	432	111	165
		134.42	17.05	287	107	160
66	Bitrignon diameter	129.61	20.18	435	118	140
		122.17	12.68	288	110	131
70	Head breadth	142.75	11.66	436	130	153
		136.85	17.32	288	124	146
79	Nose breadth	37.26	4.50	435	32	44
		34.02	4.16	288	29	40
80	Interocular breadth	30.47	4.39	435	25	35
		29.35	2.95	288	24	34
81	Biocular breadth	103.08	6.60	435	93	114
		99.40	8.69	288	87	110
82	Bizygomatic breadth	101.91	8.32	433	87	115
		99.05	9.33	288	85	114
83	Bigonial breadth	91.79	11.91	433	76	108
		87.49	12.19	288	74	102
84	Mouth height	21.11	3.24	435	16	26
		20.25	2.69	288	16	24
85	Mouth length	52.10	4.40	435	44	59
		49.84	4.35	288	43	56



No	Measurement	Mean (kg)	Standard Deviation	Number of Subjects	5th Percentile	95th Percentile
1	Weight	51.06	8.31	424	39.1	67.0
		43.37	6.55	267	34.4	56.1

To ascertain whether significant differences exist within the same population, the weight and three important dimensions viz. stature, sitting height and head circumference, were selected and their means were compared between the 7 provinces (which covered the whole country) using ANOVA. There were no significant differences in these measurements for both male and female populations, which indicated a homogeneity in body measurements among people living in one country like Sri Lanka. However the differences in means between males and females in the above measurements were highly significant ($p < 0.001$). It is believed that head and face measurements may not differ significantly between males and females in one ethnic group or society, unlike other body measurements.⁹ In the Sri Lankan survey the percentage differences in mean measurements between males and females were greater in measurements taken standing (e.g. stature) (7.09%), sitting (e.g. sitting height) (7.45%) and on hand (7.13%) and on foot (7.28%) than face measurements (5.35%) as shown in Table 1. The percentage difference was least in the head measurements (3.5% approx.). Therefore with regard to the use of head gear, special modifications in sizing, seem to be not necessary between males and females.

Table 1. Percentage differences in anthropometric data between males and females

All measurements in mm.							
	Stature (Stand)	Sitting Height (Sitt.)	Hand Length (Hand)	Foot Length (Foot)	Nasion— Menton (Face)	Head Length (Head)	Head Circum. (Head)
Meas. No.	17	8	88	61	77	65	63
Males	1639.01	1213.58	179.38	252.82	119.78	177.50	542.92
Females	1522.77	1123.15	166.59	234.41	113.37	171.25	523.51
Differ.	116.24	90.43	12.79	18.41	6.41	6.25	19.40
% Diff.	7.09	7.45	7.13	7.28	5.35	3.52	3.57

3.2 Populations Compared

Most anthropometric data available today are from the United States and other European countries with emphasis on military purposes. With regard to developing countries, anthropometric data are scarce. National data are almost non-existent, as collection of such data takes a long time and effort and is sometimes not useful and feasible, considering the vastness of some countries with regard to their geographical area and climatic and ethnic differences within the country. Due to the lack of precise data for homogenous populations even in developed countries, in this paper comparisons were made from the available data which may not be statistically consistent, but suitable enough to show the variations that exist.

The following sources of data were used to make comparisons.

- (a) Data provided by the national anthropometric survey of workers in Sri Lanka, (Reported in this paper).
- (b) Review of literature, (Data from other countries).
- (c) Results of a postal questionnaire conducted in developing countries by the authors.

In order to see whether significant variations actually exist between Sri Lankans and people from an industrially developed country e.g. Sweden, a large number of important dimensions of Sri Lankans obtained from the national survey were compared with data from Sweden.¹¹ Wherever data from Sweden were not available, data from Britain,² were substituted. It was observed that significant differences were apparent in almost all of the dimensions.

3.3 Comparison of Stature

The percentile values of stature of males of seven countries have been compared by Kennedy.¹⁰ Values of nine other populations including Sri Lankans were included and shown in Figure 3. Making use of this graph, the percentages of accommodation of a design range of 90% of the British with respect to populations of other countries were prepared, (Table 2). It was seen that only 35% of Sri Lankans could be accommodated in such a design. Gross inadequacy of a British design (based on accommodating 90% of the British population) was seen for all countries starting from Tunisia down. Remarkably, except for Japan (an industrialised country) the problem appears to be prevalent only in developing countries.

From the available data, average statures of males and females are grouped into different regions and shown in Table 3. It can be seen from this table that North American, European and Scandinavian people are tall, African and people in the Middle East are of medium height and Latin

Figure 3. Percentile values of statures of males from 16 countries

(IC) Industrialized Countries— (IDC) Industrially Developing Countries (Except Japan)

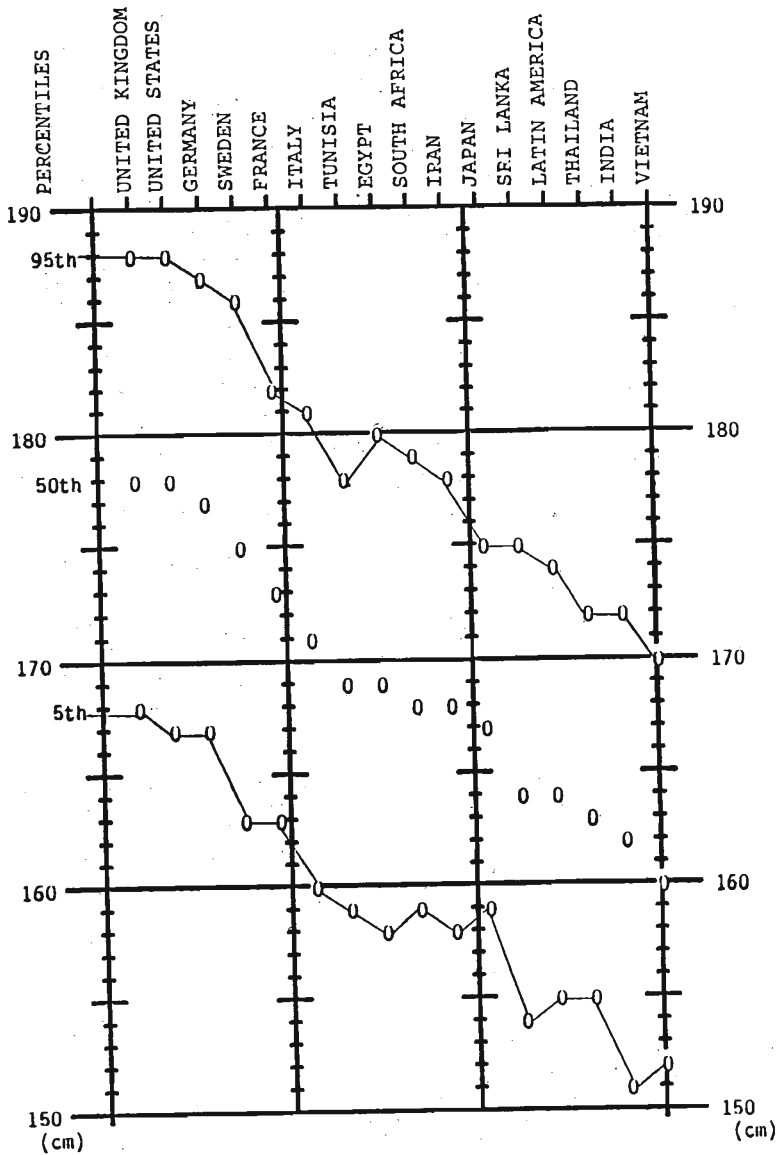


Table 2. Percentages of accommodation of 5th to 95th percentile of a British design for other populations.

Industrialized Countries (%)		Developing Countries (%)	
United States	90	Tunisia	62
Germany	90	Egypt	59
Sweden	84	South Africa	57
France	81	Iran	52
Italy	70	* Japan	43
		Sri Lanka	35
		Latin America	32
		Thailand	24
		India	22
		Vietnam	13

* An Industrialized Country

American, South East Asian (including Sri Lanka) and Far East Asian people are short. It was noted that except for Japan, people who live in IC are taller than those who live in IDC.

Table 3. Human body size variability of males from the different parts of the world

	All measurements in cm.					
	THE WEST	AFRICA	MIDDLE EAST	FAR EAST ASIA	LATIN AMERICA	SOUTH ASIA
Mean Stature	174.99	168.80	168.57	164.78	163.50	163.45
Mean Sitting Height	91.54	86.60	87.57	87.68	85.30	84.25
Mean Sit. Ht/ Mean Stature Ratio	0.523	0.513	0.520	0.532	0.522	0.516
No. of Countries	9	2	3	4	18	2

The conclusion that shorter people live in IDC may not always be true like in the example of the Japanese. Even Taiwanese from the Far East (whose data were not available at the time of writing) may be shorter people than Westerners. But Taiwan may now be classified as an IC. Therefore variability in stature and/or other dimensions can be caused by an ethnic rather than an industrial factor, although climate may also be a contributory factor, (3.5).

3.4 Comparison of Sitting Height

Figure 4 shows a graph with percentile values of sitting heights prepared and completed in the similar lines as for stature. A feature that was shown in this graph is that Japanese have higher sitting heights than the Swedish, Italians, Iranians, Tunisians and South Africans who were taller than the Japanese in stature. A proportionally longer trunk in Japanese than Europeans,¹² may be the reason why the Japanese occupy a higher sitting height. Another conspicuous finding is that the 50th percentile sitting height was more or less similar for European continent, Scandinavia and Japanese populations. This is an advantageous facility when designing machines to be operated seated including motor vehicles for the above populations. Sri Lanka occupied the last position indicating a warning signal for importers of motor vehicles, whether from the West or from Far East. It is noted that the imported motor vehicles (cars and coaches) that are mostly used in Sri Lanka do not have the vertical adjustment of the driver's seat.

3.5 Comparison of Body Proportions

Body proportions are also important to consider when designing for different populations. Tanner and others¹⁴ studied body proportions in Japanese children and adults and comparisons were made with British and with Japanese Americans. They found that Japanese now have trunk/leg proportions closer to those of North Europeans than was the case 20 years ago. Concerning relative lengths of the limbs and trunks, Pheasant¹² had made generalisations such as, African negroes have proportionally greater limb lengths (and a proportionally lesser sitting height) than Europeans and vice versa in Far Eastern samples.

Taking the stature, sitting height and body proportions together, similarities have been observed in groups of populations. Except the Koreans where average stature of 168.7 cm. appeared a little out of place, all other dimensions more or less fitted in well into the groups. Therefore taking these basic dimensions, the world populations can be conveniently divided into six main ethnic groups, viz. Caucasians from the West, Negroids from Africa, Aryans from the Middle East, Mongoloids from the Far East Asia, Latin Americans from South America and Dravidians/Aryans (include Sri Lankans) from South Asia, (Table 4).

Figure 4. Percentile values of sitting heights of males from 15 countries (Sitting heights measured from sitting surface)

(IC) Industrialized Countries — (IDC) Industrially Developing Countries

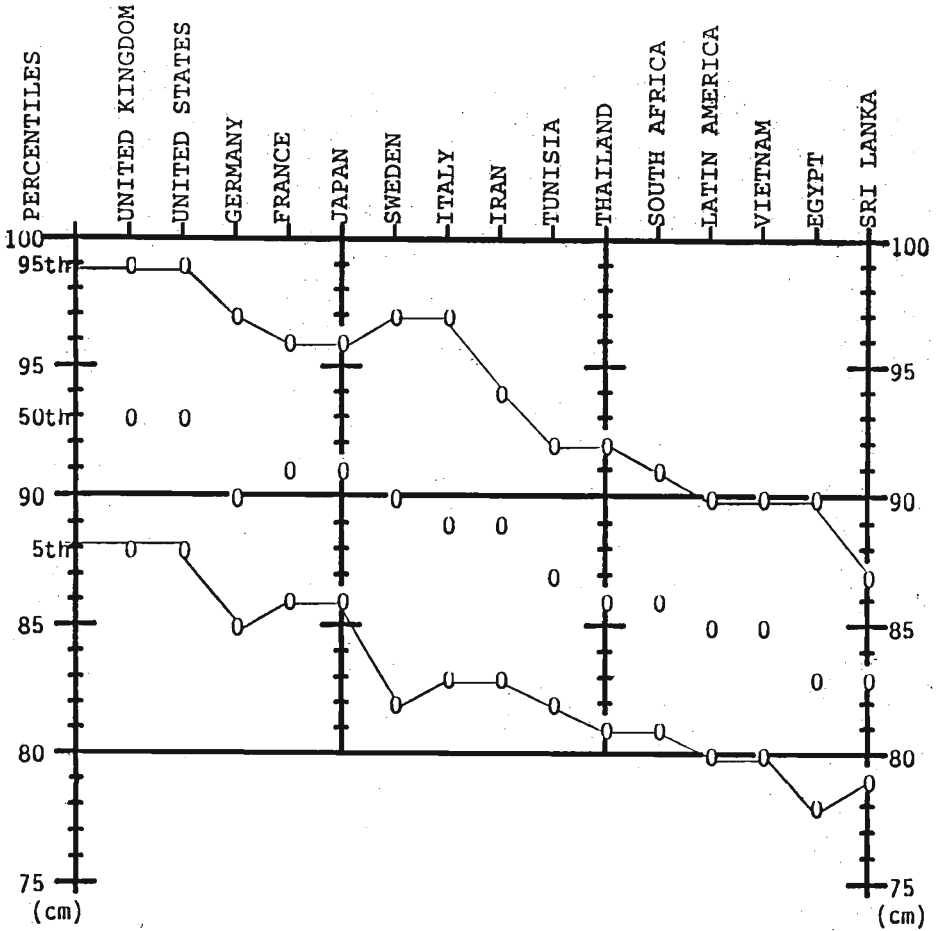


Table 4. Average statures of males and females for groups of countries in different regions
(All measurements in centimeters)

	EUROPEAN CONTIN- ENT AND SCANDIN.	NORTH AMERICA AND CANADA	MIDDLE EAST	AFRICA	FAR EAST ASIA	LATIN AMERICA	SOUTH ASIA
MALES	174.18 (9)	177.30 (2)	168.18 (4)	168.14 (9)	165.68 (9)	165.38 (21)	164.85 (4)
FEMALES	163.80 (1)	162.00 (1)	158.00 (2)	155.92 (6)	156.49 (7)	160.00 (2)	151.43 (3)

(Number of countries appears in parenthesis)

3.6 Comparison of Hand Dimensions

In the design of machine controls, hand tools and articles where manual dexterity becomes important, the hand dimensions are crucial. Data obtained from studies conducted in the past, the hand dimensions of females from different ethnic groups and countries were compared, (Table 5). The hands of West Indian females were found significantly larger than West Europeans and Indian hands.⁶ In another study, the hands of British females were found to be significantly broader than Hong Kong Chinese and Japanese hands. The Hong Kong Chinese hands were broader than Japanese hands.⁴ From the other available data the hand dimensions of African, Sri Lankan, Swedish and Egyptian females were compared. Swedish hand length was significantly greater than that of Sri Lankans and Egyptians. But African (Sudanese females) hand lengths were significantly greater than Swedish hands and Sri Lankan women's hand width significantly greater than Egyptian women.

The hand dimensions do not seem to follow the same pattern as for stature and sitting heights. Women in industrialized countries had generally larger hands. The negroid women from developing countries also had larger hands, even larger than European or Caucasian women. Women from Far East Asia, Middle East and South Asia seemed to have smaller hands.

Table 5 Mean hand measurements of females of different countries, with standard deviations and results of "t" test

All measurements in mm.

Hand Measurements	West European (W.E.) (n=51)		West Indian (W.I.) (n=20)		Indian (Panjab) (I.P.) (n=21)			
	Mean	S.D.	Mean	S.D.	Mean	S.D.		
Hand Length	174.3	9.3	184.0	9.6	178.5	9.2		
Hand Width	92.9	5.4	97.0	5.3	94.1	5.6		
Comparisons	"t" value		S/N.S		Greater Dimension			
	H. Length	H. Width	H. Length	H. Width	H. Length	H. Width		
W.I. Vs. W.E.	3.77	2.85	S	S	West In.	West In.		
			p<0.0005	p<0.005				
W.I. Vs. I.P.	1.83	1.66	S.p<0.05	N.S.	West In.	—		
W.E. Vs. I.P.	1.72	0.83	S.p<0.05	N.S.	Indian P	—		
Hand Measurements	Hong Kong Chinese (H.K) (n=100)		British (B) (n=73)		Japanese (J) (n>50)			
	Mean	S.D.	Mean	S.D.	Mean	S.D.		
Hand Width	91.48	4.47	94.1	5.6	90.0	5.0		
Comparisons	"t" value		S / N.S.		Greater Dimension			
H.K. Vs. B.	3.31		S. p < 0.0005		British			
H.K. Vs. J.	1.76		S. p < 0.05		Hong Kong Ch.			
B. Vs. J.	4.22		S. p < 0.0005		British			
Hand Measurements	Africa-Sudan (A.S) (n=512)		Sri Lanka (S.L) (n=287)		Sweden (S.) (n=279)		Egypt (E) (n=2200)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Hand Length	182.1	8.6	166.6	6.6	176.0	10.0	160.0	16.6
Hand Width	—	—	88.7	5.6	—	—	82.0	6.0
Comparisons	"t" value		S. / N.S.		Greater Dimension			
	H.L.	H.W.	H.L.	H.W.	H.L.	H.W.	H.L.	H.W.
S. Vs. S.L.	13.8	—	S.p<0.0005	—	Swedish	—		
S. Vs. E.	23.18	—	S.p<0.0005	—	Swedish	—		
A.S. Vs. S.	8.59	—	S.p<0.0005	—	African	—		
S.L. Vs. E.	—	18.87	—	S.p<0.0005	—	Sri Lanka		

3.7. Comparison of Head Dimensions

In the use of personal protective wear (ppw), viz. head gear, eye goggles, ear defenders and respirators, the head and face dimensions become important. An anthropometric survey of the head conducted by one of the authors¹ on a random sample of Sri Lankans living in England and comparison made with relevant data of the British⁸ revealed significant differences even in this part of the human body. The results indicated that 12 out of 17 measures, the differences in means were significant.

Investigations on fitting of imported ppw were continued further, by matching the actual dimensions of ppw with dimensions of the users. In a pilot study conducted by one of the authors in Sri Lanka, measurements of imported ppw were made in 16 work establishments at random. Large deviations were observed when measurements were compared (Table 6).

4. Conclusions

For a successful transfer of technology or products, a knowledge of standard data of body sizes of different populations become important. Such data although available in developed countries in many forms (though may not always national data), are scarce in developing countries. Data of Sri Lankans have now been collected and compiled using simple techniques as described in this paper, which can benefit importers, manufacturers and designers of products for Sri Lankans. It is emphasized that every country should collect national data or if such data collection is not feasible, data should be collected on a geographical or district basis of homogenous populations. It is also recommended that such data be published so that they are made available and accessible to the designers and importers of goods.

The anthropometric data given in this paper are not complete and comprehensive for design, considering the miscellaneous nature of such data required for design purposes. For example when designing safety helmets, the thickness of the hair, the angle of helmet wearing, etc., become important. Therefore the data described in this paper can be treated as basic, from which design data can be developed to fit particular items of design and particular situations.

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Table 6. Results of measurements carried out on head harness of imported industrial safety helmets, goggles and hand gloves in Sri Lanka and the relevant mean anthropometric measurements of Sri Lankan and British populations (All measurements in centimeters)

1. Industrial safety helmets with adjustable head harness
(3 types of helmets of a standard size)

Circumference (head harness) Percentile	Sri Lankan		British	
	5th	95th	5th	95th
Mean maximum = 66.0	51.5	57.0	55.4	59.8
Mean minimum = 54.0	(40th percentile = 54.0)			
Head length (head harness)				
Mean maximum = 24.0	15.6	19.4	18.8	20.9
Mean minimum = 16.5	(10th percentile = 16.4)			

2. Goggles (3 types)

	Sri Lankan	British
Mean interocular breadth (goggles = 2.5)	3.05	—
Mean biocular breadth (goggles = 13.25)	10.30	—

3. Industrial gloves

	Length* (gloves)	Breadth*	Hand length (mean)	Hand breadth (mean)
Large size			Sri Lanka	Sri Lanka
Sample 1	19.0	11.0		
Sample 2	19.0	12.5	(17.95)	(9.95)
Sample 3	20.0	13.0		
Small size				
Sample 4	15.0	12.0		

* The length and breadth on gloves were measured similar to measurements on human hands.

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