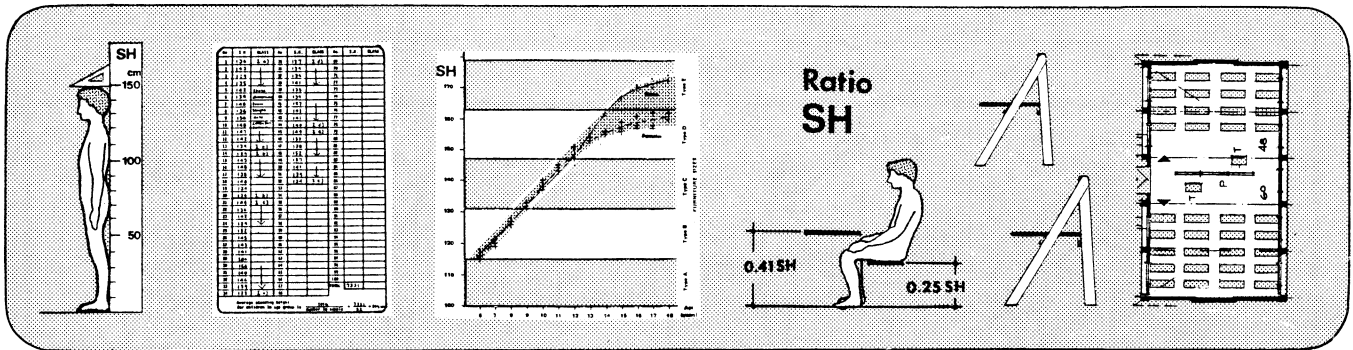


EDUCATIONAL BUILDING DIGEST 18

Unesco Regional Office for Education in Asia and the Pacific
Bangkok, Thailand

ANTHROPOMETRIC DATA AND ITS USE FOR EDUCATIONAL BUILDING AND FURNITURE DESIGN

by Evelyn Tan Guat-Lin



INTRODUCTION

In the early 1970s data on the body sizes of children in 11 Asian countries, which had been collected were analyzed and published (Unesco, 1973, 1974, 1975). Since then more recent information on standing heights of these and seven other countries has been received.

The purpose of this paper is to provide the updated anthropometric data in a useful form for designers of buildings and furniture and to provide a method of deriving anthropometric data which may be used for countries where data on children's body sizes are not available. A technique is also presented on the application of such information in furniture design.

The comfort of the student is one of the many factors likely to increase the learning effectiveness and he is comfortable in furniture that is adapted to the size of his body. If furniture is to be correctly designed, then the body measurements of the users must be known. This matching of furniture to the user's body measurements is the key issue because badly-sized furniture can affect the physical development of students as well as their academic performance.

Since the times of Vitruvius, it has been established that there is a constant ratio between the dimensions of parts of the body and the standing height (Martin, 1960). This is true in any generally related ethnic groups. A study of survey materials from various countries in the Asian region showed that there were generally no important differences in the ratios of the body-parts from one country to another. Thus, the most important dimension is that of standing height and using this system of proportion, it is possible to deduce part-body measurements from the standing height.

Some of the dimensions commonly used for the design of educational furniture and buildings are shown in

Figure 1 and listed in Table 1. These dimensions are all given as ratios to standing height. Besides the conventional postures of standing and sitting, other seating postures traditional to the region—"lotus", "sideways tuck" and "squatting" are also included.

All body dimensions increase from birth to late teens or early twenties. Between the ages of five and fourteen years, children of both sexes grow very rapidly. Therefore, in the design of furniture for schools, a variety of furniture sizes would be necessary in order to cater to the differences in body sizes with age. At some stage in the design process, a judgement has to be made on the grouping of elements of approximately similar size and the subsequent use of the elements by children from several age groups. Thus, it is also necessary to know a series of part-body measurements corresponding to the different age groups for which the furniture is to be designed.

There is a continuing worldwide trend toward and increase in height and most other body dimensions. For example, a review of data on Japanese male children revealed that the standing height and weight had increased consistently over a period of 30 years (Figure 2). This secular increase in size may be attributed to a number of factors - viz. the increase in per capita income, and availability of protein food, coupled with a general increase in educational level of mothers, who essentially have become more aware of nutritional values, have improved eating habits and the general nutritional status of the children with each decade.

It should be noted that data received from some Asian countries is more than ten years old. It is possible that secular changes in size may be large enough to invalidate anthropometric surveys of earlier decades. Thus, it is advisable for these countries to conduct another anthropometric survey.

Figure 1. Dimensions used for design of educational furniture and buildings: Ratio to standing height

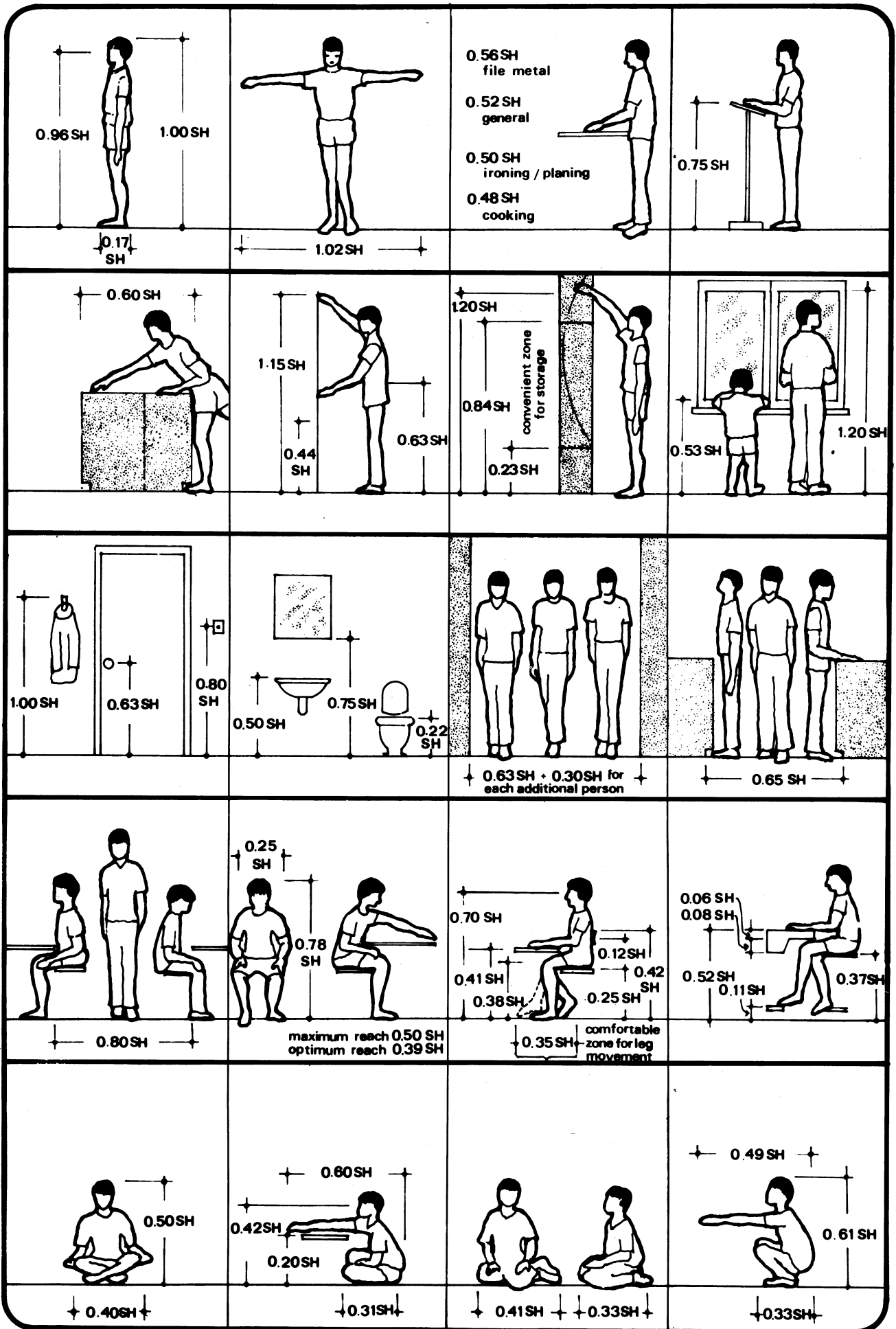


Table 1. Ratios between standing height and dimensions used in educational furniture and building design

Standing Posture	Ratio	Circulation Spaces	Ratio
Standing height	1.00 SH	Width of corridor for 2 persons	0.63 SH
Eye height	0.96 SH	Circulation space between 2 standing work surfaces	0.65 SH
Depth of body, standing	0.17 SH	Circulation space between 2 sitting work surfaces	0.80 SH
Arms outstretched, length end to end	1.02 SH		
Working Surface Standing		Working Surface Seated	
Height of work surface – general	0.52 SH	Height of desk/table	0.41 SH
– for ironing/planing	0.50 SH	*Width of desk/table	0.40 SH
– for cooking	0.48 SH	Reach – maximum	0.50 SH
– for filing metal	0.56 SH	– optimum	0.39 SH
Height of lectern	0.75 SH		
Forward Reach – maximum	0.53 SH		
– optimum	0.34 SH		
*Sizes of work surfaces are often given in absolute dimensions. ARISBR recommends 45cm x 55cm for 6 to 12 years of age and 45cm x 70cm for 12 years to adult.			
Vertical Surface (chalkboard and storage)		Ratio	
Upper reach	1.15 SH	Depth of storage	0.23 SH
Lower reach	0.44 SH	Optimum distance of subject from storage	0.46 SH
Eye height	0.90 SH	Windowpane – upper reach	1.20 SH
Elbow height	0.63 SH	– lower reach	0.53 SH
Reach – maximum	1.28 SH	Height of hook	1.00 SH
–optimum	1.10 SH	Height of door knob	0.63 SH
Storage – convenient lower storage height	0.23 SH	Height of switch	0.80 SH
convenient upper storage height	0.90 SH	Height of lower edge of mirror	0.75 SH
Height of shelf which can be reached but not seen	1.06 SH	Hight of sink top	0.50 SH
Height of shelf which can be reached and seen	0.94 SH	Hight of toilet seat	0.22 SH
Sitting Posture		Ratio	
Seated height	0.78 SH	Shoulder width	0.25 SH
Seated eye height	0.70 SH	Top of backrest to floor	0.42 SH
Elbow height	0.65 SH	Optimum height of backrest to seat	0.12 SH
Height of seat (popliteal height)	0.25 SH	Top of backrest to seat	0.19 SH
Width of seat (hip width)	0.25 SH	Angle of seat	
Front of knee to buttock	0.34 SH	0–5° slope backwards for listening and relaxing	
Depth of seat	0.24 SH	0° or slightly forward for reading or writing	
Floor to top of thigh	0.38 SH	Curve of backrest 5–8°	
Thigh thickness	0.08 SH	Height of stool	0.37 SH
Distance between desk top and top of thigh	0.06 SH	Width of stool	0.20 SH
Comfortable zone for leg movement from front of table	0.35 SH	Depth of stool	0.16 SH
		Height of footrest	0.11 SH
Other Postures		Ratio	
Sitting Lotus		Sitting Sideways Tuck	
Sitting lotus height	0.50 SH	Maximum width	0.41 SH
Sitting lotus eye height	0.42 SH	Maximum depth	0.33 SH
Knee to knee width	0.40 SH		
Sitting lotus depth	0.31 SH	Squatting	Ratio
Sitting lotus forward reach	0.60 SH	Squatting height	0.61 SH
Work surface top from floor, sitting lotus	0.20 SH	Squatting depth	0.33 SH
		Squatting forward reach	0.49 SH

Table 2. Standing heights by growth rate group of children in 20 countries in Asia and the Pacific

standing height range **120–125**

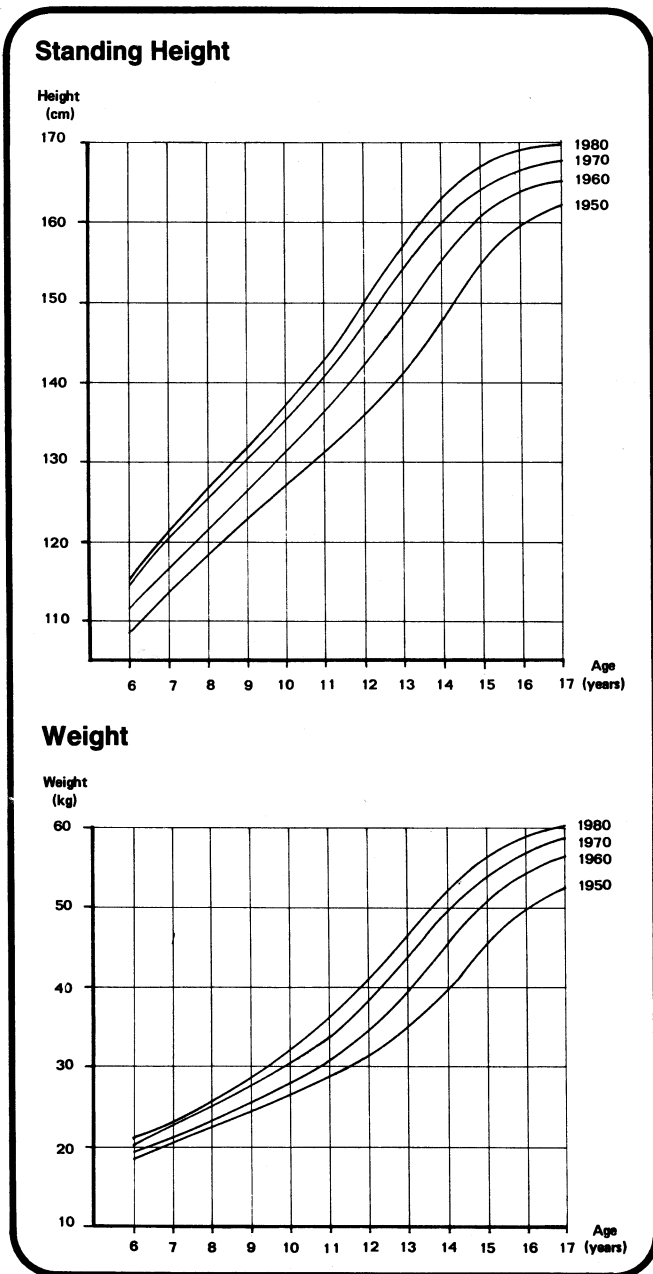
standing height range **145–150**

Country	Sex	Standing Height (cm) at each (years)													
		5	6	7	8	9	10	11	12	13	14	15	16	17	18
Group I															
Australia (1970–72)	M	110	116	122	127	132	137	142	142	148	154	161	167	171	174
	F	108	115	120	126	131	137	143	148	153	156	159	161	162	162
Japan (1980)	M	110	116	121	127	132	137	143	150	157	163	167	169	170	–
	F	109	115	121	126	132	136	145	151	154	156	156	157	157	–
Singapore (1981)	M	–	118	119	125	132	138	142	145	155	162	166	170	170	172
	F	–	116	119	127	133	138	143	147	154	155	157	158	158	160
Tonga (1984)									138						
									140						
Group II															
Papua New Guinea (1981)	M	–	–	124	126	119	128	130	135	146	158	163	164	–	–
	F	–	–	125	129	126	140	132	136	153	158	159	157	–	–
Afghanistan (1973)	M	–	112	118	124	128	132	134	140	147	154	155	169	167	173
	F	–	113	118	123	130	133	138	144	150	157	157	–	168	–
Bangladesh (1981)	M	104	114	117	122	127	132	137	140	142	150	160	163	163	165
	F	107	112	119	122	124	132	135	140	142	147	150	152	155	160
Iran (1972)	M	109	113	118	123	127	132	137	141	145	150	154	159	–	–
	F	106	112	116	121	126	131	136	142	147	150	153	155	–	–
Korea, R.O. (1979)	M	–	115	120	125	129	134	139	144	150	156	162	166	167	–
	F	–	114	119	124	129	134	140	146	151	154	155	156	157	–
Malaysia (1981)	M	–	114	119	122	129	131	135	144	149	155	161	166	168	168
	F	–	107	120	117	126	129	139	147	157	156	154	157	158	161
Sri Lanka (1971)	M	110	112	118	124	128	133	139	143	149	154	159	164	166	167
	F	109	111	114	121	125	130	137	144	149	152	153	153	154	154
Thailand (1979)	M	106	113	116	121	131	135	135	139	147	153	159	161	163	164
	F	107	112	116	120	126	132	137	142	147	150	152	153	154	155
Group III															
Philippines (1975)	M	102	107	112	117	122	126	132	137	145	150	157	161	162	163
	F	102	107	112	117	122	128	134	140	145	149	151	151	151	151
Bhutan (1984)	M	102	106	111	116	121	122	127	135	141	146	153	157	162	166
	F	100	107	113	115	122	125	132	136	138	148	152	155	156	156
India (1970)	M	–	105	112	117	122	127	130	135	140	144	153	156	–	–
	F	–	102	109	116	121	128	131	137	143	147	148	149	–	–
Kampuchea (1973)	M	109	110	113	117	120	125	130	135	141	149	154	160	163	163
	F	104	109	112	116	121	124	130	134	143	148	151	153	153	154
Laos (1981)	M	–	–	110	111	113	116	129	139	139	143	145	–	–	–
	F	–	–	109	110	112	116	122	133	137	141	144	–	–	–
Nepal (1979–81)	M	–	101	109	111	119	123	128	134	137	148	153	160	162	161
	F	–	105	112	115	118	126	132	138	145	150	150	152	151	–
Indonesia (1972)	M	–	109	112	116	119	122	127	133	138	147	153	158	162	163
	F	–	109	113	115	119	123	128	135	140	148	151	152	154	154
Maldives (1974)	M	103	105	110	119	122	124	125	132	130	134	140	–	–	–
	F	101	106	109	116	118	123	127	131	132	138	147	–	–	–
standing height															
Group I	M	110	117	121	127	132	137	142	148	155	162	167	170	171	173
	F	109	115	120	126	132	138	144	149	154	156	157	159	159	161
Group II	M	106	113	119	123	126	132	136	141	147	154	159	164	166	167
	F	106	112	118	122	127	133	137	143	150	153	154	155	158	158
Group III	M	105	106	111	116	120	123	129	135	138	145	151	159	162	163
	F	102	103	111	115	119	124	129	135	141	148	149	151	152	153

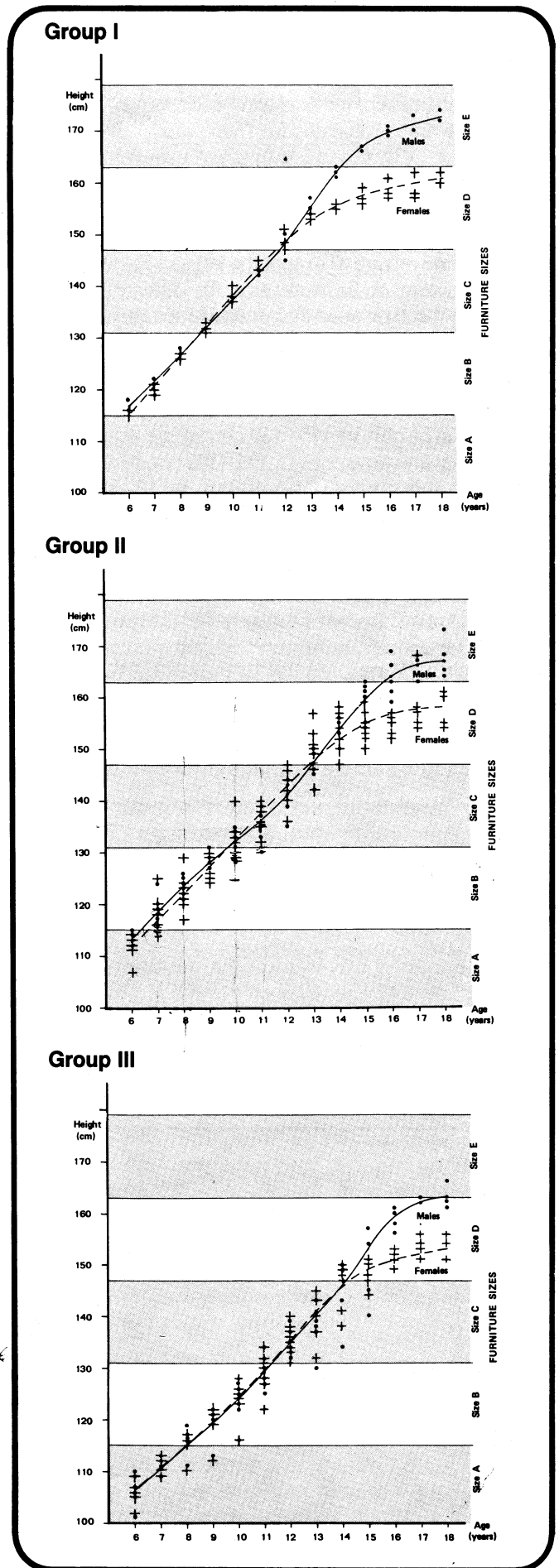
ANTHROPOMETRIC DATA OF THE ASIA AND PACIFIC REGION

Table 2 shows the average standing heights of male and female students aged 5 to 18 years from 19 countries in Asia and the Pacific. The standing height with age data have been classified into three groups of growth rates labelled I, II and III. There is the equivalent of one to two years difference in standing heights between each group. For example, a 13 year old Indonesian male is the same height as an 11 year old Sri Lankan male and a 10 year old Japanese male. Group I countries include Japan, Australia, Tonga and Singapore; three which, coincidentally, have developed economies. Group II comprises Afghanistan, Bangladesh, Iran, Korea, Malaysia, Papua New Guinea, Sri Lanka and Thailand. Group III includes Bhutan, India, Indonesia, Democratic Kampuchea, the Lao Peoples' Democratic Republic, Maldives, Nepal and the Philippines (see graphs in Figures 3, 4 and 5).

Figure 2. Japanese male height and weight versus age



Figures 3, 4 and 5 Average standing height versus age (Group I, II and III)



FURNITURE SIZES

The designer has to decide on the number of sizes of furniture to be manufactured. It is usually most economical to decide on a minimal number of furniture sizes to fit the school population.

From the data of the Asia and Pacific region, five sizes of Furniture are recommended. These are labelled as furniture size A, B, C, D and E with size A being the smallest size and size E the largest. For any country, only four size would be needed. Thus countries in Groups I and II will require all except the smallest size of furniture while those in Group III will require all except the largest. Table 3 shows the distribution of furniture size for different ages in Groups I-III. It can be seen that while Groups I and II will use the same four furniture size, each size is suited to children of different ages with each group.

For those countries in Group I, furniture size B which fits standing heights of 115–130 cm, will be used by 6–9 year old girls and boys; size C, 131–140 cm, by 9–12 year old girls and boys; size D, 147–162 cm, by 12–18 year old girls and 12–14 year old boys and size E, 163–179 cm, by 14–18 year old girls and boys.

USING THE ASIA AND PACIFIC DATA

Let us consider that country 'X' would like to design furniture for school children and no anthropometric data was available. By following the six steps described below, furniture which fits the great majority of students can be designed.

1. Selecting a sample of children for measurement

Two sampling techniques exist. Method 'A' below gives accurate results which are specific to the country. However arriving at the average standing height requires considerable time and resources. Method 'B' will give approximate results but is much easier to implement.

- A. The designer may measure the standing height of a sample of children of each of the 5 to 17 years age groups. Those who are processing the data should ensure that the population from which the random

sample is taken includes all socio-economic groups in the country. A sample giving a reasonable degree of reliability must be chosen. Random samples of sizes 300 to 500 children for each year of age have been used. Figure 6 shows an example of the data and calculations form. Thus, a curve showing the standing height versus age relationship is obtained from the population of that country.

- B. The standing heights of a random sample of 100 children in one of the age groups are measured. Then the average height of that age group is calculated. This average height is compared with data from the Asia and Pacific region (Table 2). The growth curve of a country which has a similar height at the same age as that of country 'X' is identified from Figures 3, 4 or 5. We can then use the curve which gives the standing height versus age relationship of this population in a number of Asian countries to represent that of country 'X'

For example, Tonga had recently measured the standing heights of a sample of 100 boys and girls of age 10 years, the average values being 138.4 ± S.D. 6.6 cm for boys (n=46) and 140.3 ± S.D. 6.3 cm for girls (n=54). The average values matched those of the Group I countries (Table 2, Figure 3). It can be assumed that children of all ages in Tonga will be similar in height to group I countries. We therefore use the standing heights of group I countries to represent that of Tonga.

2. Measurement of standing height of persons in the sample

A measuring scale is drawn on or attached to a wall of the classroom. Each child is measured standing barefoot with his back against the wall (Figure 7). He has to stand erect and look straight ahead, making four points of contact with the wall, the back of his head, his shoulders, his buttocks and his heels. Using a right angle square, the teacher places the straight edge on top of the child's head, and the other straight edge against the measuring scale on the wall. The height of the student is taken as the reading on the underside of the horizontal edge. Measurements should be made by the teacher to the nearest centimetre.

Table 3. Furniture sizes suitable for standing height and age ranges by group of countries

Furniture Size	Standing Height (cm)		Corresponding Age Range in Each Group (M: Male F: Female)					
	Range	Midpoint	Group I		Group II		Group III	
A	115	108	-		-		6-8	M+F
B	115-130	123	6-9	M+F	6-10	M+F	8-12	M+F
C	131-146	139	9-12	M+F	10-13	M+F	12-14	M+F
D	147-162	155	12-14	M	13-16	M	14-17	M+F
E	163-179	171	12+	F	13+	F		
			14+	M	16+	M		

Figure 6 Tabulation of average standing heights of children

No.	Age	Sex	Standing height in cm	No.	Age	Sex	Standing height in cm
1	11	f	136	31	15	f	151
2			142	32	15	f	152
3			129	33			
4			135	34			
5			142	35			
6			139	36			
7			148	37			
8			136	38			
9			156	39			
10			148	40			
11			147	41			
12			142	42			
13	11		139	43			
14	12		141	44			
15			148	45			
16			138	46			
17			146	47			
18			129	48			
19			146	49			
20	12		153	50			
21	13		134	51			
22	13		140	52			
23	13		144	53			
24	13		140	54			
25	14		152	55			
26	14		163	56			
27	14		156	57			
28	15		158	58			
29	15		156	59			
30	15	f	152	60			

Note: these heights are to be transferred to the "calculation form" together with the heights of all 11-year-old girls in other grades in the school in order to calculate the average standing height of 11-year-old girls, the range of heights and the standard deviation

1. Start measuring the students with the lowest age and finish with the students with the highest age.
2. Sex : Fill in f for female, and m for male.
3. Use one sheet per class.

No.	S.H.	CLASS	No.	S.H.	CLASS	No.	S.H.	CLASS
1	136	I a)	35	137	I d)	69		
2	142		36	139		70		
3	129		37	139		71		
4	135		38	141		72		
5	142	these	39	135		73		
6	139	dimensions	40	139		74		
7	148	from	41	157		75		
8	136	sample	42	143		76		
9	156	data	43	141		77		
10	148	collection	44	140	I d)	78		
11	147	form "	45	149	I e)	79		
12	142		46	133		80		
13	139	I a)	47	138		81		
14	129	I b)	48	152		82		
15	145		49	137		83		
16	148		50	141		84		
17	138		51	139		85		
18	148		52	134	I e)	86		
19	134		53			87		
20	134	I b)	54			88		
21	144	I c)	55			89		
22	136		56			90		
23	142		57			91		
24	129		58			92		
25	152		59			93		
26	145		60			94		
27	143		61			95		
28	141		62			96		
29	146		63			97		
30	154		64			98		
31	140		65			99		
32	146		66			100		
33	139		67			TOTAL	7331	
34	125	I c)	68					

Average standing height for children in age group is $\frac{\text{TOTAL}}{\text{number in sample}} = \frac{7331}{52} = 144 \text{ cm}$

3. Use of system of proportions

After obtaining the standing heights of the age groups from either sampling method, the part-body measurements and furniture dimensions at each age group may be calculated by using the ratios given in Figure 1 and Table 1. For example average shoulder width can be estimated by

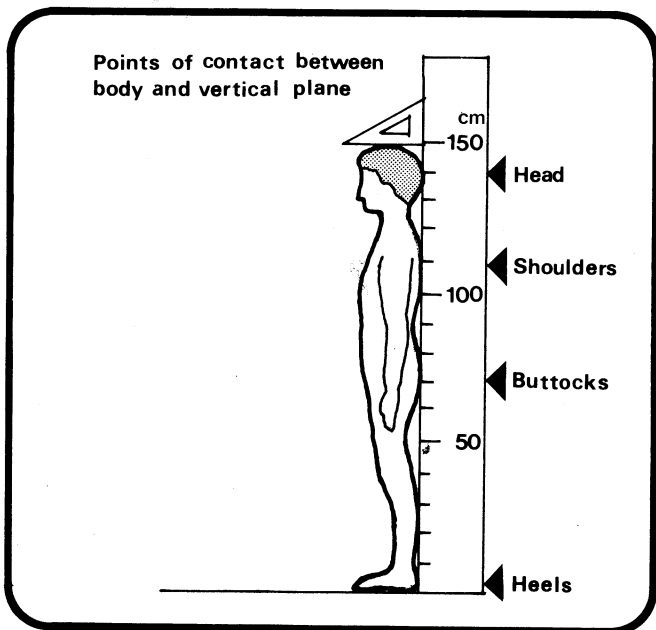
multiplying the ratio 0.25 and the average standing height.

4. Sizing of furniture

After deriving the standing height versus age relationship for country 'x' the designer identifies from Table 2 and Figures 3-5, to which growth group it belongs, and the range of furniture sizes that is required. He, then, identifies the relevant part-body measurements which are required to determine the optimum sizes of various parts of the furniture. For example, in the case of a chair, the relevant part-body measurements are the popliteal height or lower leg measurement (which is the point where the leg bends at the back of the knee to the heel) to fix the height of the seat; the upper leg measurement (from the popliteus to the back of the buttock) to fix the depth of the seat; the hip width and the shoulder width to fix the width of the seat. Using Table 4, the designer can directly convert the ratios of part-body measurements to standing height into actual measurements for each furniture size.

This paper advises a total of five size of furniture, and within this range, comfortable furniture should be found for most of the children in a school. Sizing furniture to fit an age range is more difficult than sizing a set to fit an individual. In this context, the concept of "margins of tolerance" (i.e., the tolerable misfit of furniture) is more important than fit. The permissible margins of tolerance (Unesco, 1979) for chairs, for example, are established as a "tolerance below fit" of 4.0 cm and a "tolerance above

Figure 7. Measurement of standing height



fit" of 7.0 cm. This order of tolerance is still considerably less than that accepted by most parents for their children at home—when a six year old sits in an adult chair at the dining table the tolerance above fit is about 11.0 cm.

Let us take the example of one furniture dimension and calculate the "margins of tolerance" afforded by the five sizes, A–E, for countries in each group in order to determine whether the tolerances are within acceptable limits. The furniture dimension is seat height, and the lower leg measurement can be calculated as 0.25 of standing height. Alternatively by using Table 4, the actual values of 0.25x standing height can be read directly from the table.

In Tables 5 these tolerances have been calculated for the entire range of 6–18 years in Groups I–II countries. For Group I countries, the recommended seat heights (size B–E) are 1.2–2.0 cm higher than fit and 0.2–1.5 cm below fit. For Group II countries, the recommended seat heights (size B–E) are 0.3–1.0 cm above fit and 1.2–2.7 cm below fit. As for Group III countries, the recommended seat heights show tolerances which are acceptable, 0.5–1.2 cm above fit and 1.3–1.8 cm below fit. In all cases, tolerances afforded by the five sizes of seat heights are within the acceptable "margins of tolerance".

The same procedure can be used for estimating the margins of tolerance of other dimensions of the furniture.

5. Allocation of furniture types

The question of how many pieces of furniture of each size are required in each school and each class is discussed here. The exact distribution of chairs and tables by size will depend upon the pattern of distribution of school children by age in the area for which the furniture is required.

In the case of a country which has had compulsory primary education for some time, most of the children in each class will be of the same age and a few will be slightly older than the majority due to non-promotion. In this case, it would be fairly easy to arrange the distribution of desks and chairs by size. The design of each chair and table incorporates appropriate information for an age range of 3 years, so that almost all of the children of each age group will be able to use the furniture designed for their group and only a small percentage of the children will require furniture which is either too small or too large for their age group.

However, in countries where compulsory primary education has not been achieved, or in countries where

primary education has commenced recently, there is low retention due to drop out and non-promotion. Furthermore, it is likely that in most grades there is a large percentage of over-age pupils. It will be necessary to provide some furniture for students who are three to four years older than those for which the class is intended. In this case, three sizes of furniture for a class of 40 will be allocated, the numbers of each size will depend on the age distribution in the intended class.

It is important to note that there are no significant differences in the average standing heights between girls and boys at each age from 6 to 14 years old. The differences become considerable at puberty, after the age of 14 years when male height increases rapidly above that of females. Thus in primary schools, the same furniture can be used by both sexes of the same age. For classes of children of 14 years and above, boys schools may require a different furniture distribution from that of girls schools. Where there is co-education, the percentages of students of certain age range per grade can be calculated for the mixed sample. It should be emphasized again that the exact distribution of furniture by size will depend upon the age distribution of the school children and not the grade in the area for which the furniture is required.

6. Suitable matching of seat to table top

If different sizes of furniture have been provided, it is important that a right combination of seat and table is selected, to avoid resulting in small children sitting relatively large tables and seats and conversely older children sitting at relatively small tables and seats. What is even more serious, the furniture frequently becomes mismatched, resulting in children using small chairs with large tables and vice versa. This problem can be avoided by clear coding of the furniture sizes to ensure that the furniture is correctly matched and used.

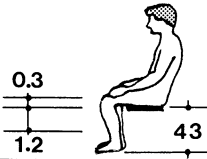
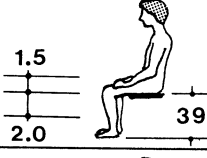
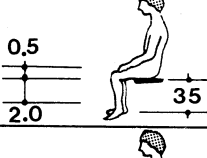
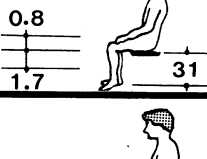
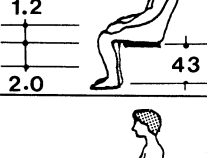
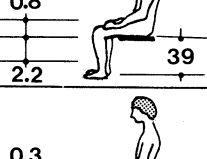
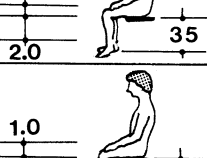
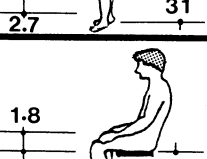
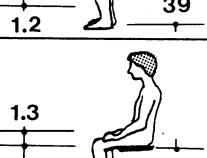

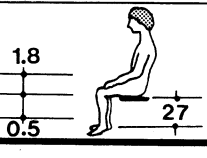

CONCLUSION

By carefully following the six steps above, physically comfortable environments for learning can be created. The material has been presented in a form which should be easily followed by those who are responsible for the design and use of educational buildings and furniture. The contents of this study are independent of the materials used for building construction and furniture manufacture. It can, therefore, be applied throughout the Asia and Pacific region.

Table 4. Design Dimensions for furniture sizes in centimetres and inches

Average Standing Height Ranges	A	B	C	D	E	A	B	C	D	E
	115	115-130	131-146	147-162	163-179	45.3	45.3-51.2	51.3-57.5	57.6-63.8	63.9-70.5
Midpoints	108	123	139	155	171	42.5	48.4	54.7	61.0	67.3
Ratios	Design Dimensions (centimeters)					Design Dimensions (inches)				
0.06	6	7	8	9	10	2.4	2.8	3.2	3.5	3.9
0.08	9	10	11	12	14	3.5	3.9	4.3	4.7	5.5
0.11	12	14	15	17	19	4.7	5.5	5.9	6.7	7.5
0.12	13	15	17	19	21	5.1	5.9	6.7	7.5	8.3
1.16	17	20	22	25	27	6.7	7.9	8.7	9.8	10.6
0.17	18	21	24	26	29	7.1	8.3	9.5	10.2	11.4
0.19	21	23	26	29	32	8.3	9.1	10.2	11.4	12.6
0.20	22	25	28	31	34	8.7	9.8	11.0	12.2	13.4
0.23	25	28	32	36	39	9.8	11.0	12.6	14.2	15.4
0.24	28	30	33	37	41	10.2	11.8	13.0	14.6	16.1
0.25	27	31	35	39	43	10.6	12.2	13.8	15.4	16.9
0.33	36	41	46	51	56	14.1	16.1	18.1	20.1	22.1
0.34	37	42	47	53	58	14.5	16.5	18.5	20.8	22.8
0.35	38	43	49	54	60	15.0	16.9	19.3	21.3	23.6
0.37	40	48	51	57	63	15.8	18.1	20.1	22.4	24.8
0.38	41	47	53	59	65	16.1	18.5	20.9	23.2	25.6
0.39	42	48	54	60	67	16.5	18.9	21.3	23.6	26.4
0.40	43	49	58	62	68	16.9	19.3	22.1	24.4	26.8
0.41	44	50	57	64	70	17.3	19.7	22.4	25.2	27.6
0.42	45	52	58	65	72	17.7	20.5	22.8	25.6	28.4
0.44	48	54	61	88	75	18.9	21.3	24.0	26.8	29.5
0.48	50	57	64	71	79	19.7	22.4	25.2	28.0	31.1
0.48	52	59	67	74	82	20.5	23.2	26.4	29.1	32.3
0.49	53	60	68	76	84	20.9	23.6	26.8	29.9	33.1
0.50	54	62	70	78	86	21.3	24.4	27.6	30.7	33.9
0.52	56	64	72	81	89	22.0	25.2	28.4	31.9	35.0
0.53	57	65	74	82	91	22.4	25.6	29.2	32.3	35.8
0.56	60	69	78	87	96	23.6	27.2	30.7	34.3	37.8
0.60	65	74	83	93	103	25.6	29.1	32.7	36.6	40.6
0.61	66	75	85	95	104	26.0	29.5	33.5	37.4	41.0
0.63	68	78	88	98	108	26.8	30.7	34.7	38.6	42.5
0.65	70	80	90	101	111	27.6	31.5	35.4	39.8	43.1
0.70	76	86	97	109	120	29.9	33.9	38.2	42.9	47.2
0.71	77	87	99	110	121	30.3	34.3	39.0	43.3	47.6
0.75	81	92	104	116	128	31.9	36.2	41.0	45.7	50.4
0.78	84	96	108	121	133	33.1	37.8	42.5	47.6	52.4
0.90	97	111	125	140	154	38.2	43.7	49.2	55.1	60.6
0.94	102	116	131	146	161	40.2	45.7	51.6	57.5	63.4
0.96	104	118	133	149	164	41.0	46.5	52.4	58.7	64.6
0.02	110	125	142	158	174	43.3	49.2	55.9	62.2	68.5
1.06	114	130	147	164	181	44.9	51.2	57.9	64.6	71.3
1.10	119	135	153	171	188	46.9	53.1	60.2	67.3	74.0
1.28	138	157	178	198	219	54.3	61.8	70.1	78.0	86.2

Table 5. Acceptable tolerance for seat heights.

AGE (year)	MALE		Acceptable Tolerance (cm)	Recommen- ded Popliteal Height for seat (cm)	Furniture size		
	Standing Height (cm)	Popliteal Height (cm)					
Group I	18	173	43.3		43	E	The seat height for size E is 43 cm. This is 0.3 cm below 43.3 cm, the popliteal height for 18 year olds. At the lower limit this height will suit 15 year olds with popliteal height of 41.8 cm, being 1.2 cm above fit.
	17	171	42.8				
	16	170	42.5				
	15	167	41.8				
Group I	14	162	40.5		39	D	Size D seat height is 38 cm, this 1.5 cm below 40.5 cm which is the popliteal height for 14 year olds. At the lower limit, this height will suit 12 year olds, with 37.0 cm popliteal height being 2.0 cm higher than fit.
	13	155	38.8				
	12	148	37.0				
Group I	11	142	35.5		35	C	Size C seat height is 35 cm, which is 0.5 cm below 35.5 cm, the popliteal height for 11 year olds. At the lower limit, the height will suit 9 year olds of popliteal height 33.0 cm, being 2.0 cm above fit.
	10	137	34.3				
	9	132	33.0				
Group I	8	127	31.8		31	B	Size B seat height is 31 cm. This is 0.8 cm below 31.8 cm, the popliteal height of 8 year olds. At the lower limit, it will suit 6 year olds with popliteal height of 29.3 cm, being 1.7 mm higher than fit.
	7	121	30.3				
	6	117	29.3				
Group II	18	167	41.8		43	E	The seat height for size E is 43 cm. This is 1.2 cm above 41.8 cm, the popliteal height for 18 year olds. At the lower limit this height will suit 16 year olds with popliteal height of 41.0 cm, being 2.0 cm above fit.
	17	166	41.5				
	16	164	41.0				
	15	159	39.8				
Group II	15	159	39.8		39	D	Size D seat height is 39 cm, this 0.8 cm below 39.8 cm which is the popliteal height for 15 year olds. At the lower limit, this height will suit 13 year olds, with 36.8 cm popliteal height being 2.2 cm higher than fit.
	14	154	38.5				
	13	147	36.8				
Group II	12	141	35.3		35	C	Size C seat height is 35 cm, which is 0.3 cm below 35.3 cm, the popliteal height for 12 year olds. At the lower limit, the height will suit 10 year olds of popliteal height 33.0 cm, being 2.0 cm above fit.
	11	136	34.0				
	10	132	33.0				
Group II	9	128	32.0		31	B	Size B seat height is 31 cm. This is 1.0 cm below 32.0 cm, the popliteal height of 9 year olds. At the lower limit, it will suit 6 year olds with popliteal height of 28.3 cm, being 2.7 cm higher than fit.
	8	123	30.8				
	7	119	29.8				
	6	113	28.3				
Group III	18	163	40.8		39	D	Size D seat height is 38 cm, this is 1.8 cm below 40.8 cm, the popliteal height for 18 year olds. At the lower limit this height will suit 15 year olds with popliteal height of 37.8 cm, being 1.2 cm above fit.
	17	162	40.5				
	16	159	39.8				
	15	151	37.8				
Group III	14	145	36.3		35	C	Size C seat height is 35 cm. This is 1.3 cm below the popliteal height (36.3 cm) of 9 year olds. At the lower limit, it will suit 12 year olds with popliteal height of 33.8 cm being 1.2 cm higher than fit.
	13	138	34.5				
	12	135	33.8				
Group III	11	129	32.3		31	B	Size B seat height of 31 cm is 1.3 cm below the popliteal height (32.3 cm) of 11 year olds. At the lower limit, it will suit 9 year olds with popliteal height of 30 cm being 1.0 cm above fit.
	10	123	30.8				
	9	120	30.0				
Group III	8	115	28.8		27	A	Size A seat height of 27 cm is 1.8 cm below 28.8 cm, the popliteal height of 8 year olds. At the lower limit it will suit 6 year olds with popliteal height of 26.5 cm, being 0.5 cm higher than fit.
	7	111	27.8				
	6	106	26.5				

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No.	Age	Sex	Standing height in cm	No.	Age	Sex	Standing height in cm
1				31			
2				32			
3				33			
4				34			
5				35			
6				36			
7				37			
8				38			
9				39			
10				40			
11				41			
12				42			
13				43			
14				44			
15				45			
16				46			
17				47			
18				48			
19				49			
20				50			
21				51			
22				52			
23				53			
24				54			
25				55			
26				56			
27				57			
28				58			
29				59			
30				60			

No.	S.H.	CLASS	No.	S.H.	CLASS	No.	S.H.	CLASS
1			35			69		
2			36			70		
3			37			71		
4			38			72		
5			39			73		
6			40			74		
7			41			75		
8			42			76		
9			43			77		
10			44			78		
11			45			79		
12			46			80		
13			47			81		
14			48			82		
15			49			83		
16			50			84		
17			51			85		
18			52			86		
19			53			87		
20			54			88		
21			55			89		
22			56			90		
23			57			91		
24			58			92		
25			59			93		
26			60			94		
27			61			95		
28			62			96		
29			63			97		
30			64			98		
31			65			99		
32			66			100		
33			67			TOTAL		
34			68					

Average standing height for children in age group is $\frac{\text{TOTAL}}{\text{number in sample}} = \frac{\quad}{\quad} = \quad \text{cm}$