

Work Space Recommendations on the Basis of Anthropometric Measurements of Punjabi Women

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ABSTRACT Present study was conducted on a sample of 240 females from two approved and two unapproved localities of Ludhiana city having reference height 153 cms (ICMR 2004) \pm 12.5 cms, similar weight and body stature. Results indicated that Buttock-knee length varied between 49.48 – 54.8 cms; buttock - popliteal length: 44.45 – 49.12; total arm, forearm, hand and foot length ranged from 63.67 – 64.87; 36.47 – 39.32; 14.65 – 19.85 and 18.82 – 21.72 cms respectively. Shoulder and hip breadth (in standing and sitting posture) ranged between 37.57 – 38.38; 36.58 – 37.37; 30.48 – 30.95 and 30.62 – 31.48 cms respectively. Elbow to elbow and knee breadths were: 43.98 – 46.8 and 18.60 – 20.05 cms. Maximum to normal vertical reaches lied between 168.57 – 100.3 to 161.35 – 182.25 cms; horizontal reach: 68.85 – 74.25 to 61.5 – 66.9; side reach; 64.07 – 71.65 and normal reach: 92.27 – 103.92 cms. Recommended space allowances in square meters were: kitchen activities – .37 \pm .009; washing clothes, ironing, stitching, cutting, drafting- .41 \pm .05. Space needed in front of refrigerator and washing machine, for serving seated person was 92.5 \pm 2.5, for opening drawer – 120 cms. Recommended sink width, depth and sides were 50, 17.5, and 62.5 \pm 2.5 cms respectively. Minimum space requirement for bed making – 92.5 \pm 5, around dining table - 75 \pm 2.5 and around seated person – 90 \pm 2.5. to clean under bed, dining table and other furniture optimum recommended space was 50 \pm 2.5, 57.5 \pm 5 and 70 \pm 5 cms respectively.

INTRODUCTION

Work space that people require depends upon the elbow room needed for their job and for their psychological satisfaction. The physical need for space is determined by the size of person, specially length and breadth dimensions and body reaches, the space needed to move around furniture and equipment and the space needed for passage to an fro i.e. circulation space (Bratton and Steidl, 1968).

In India, for allocating work spaces for performing household activities like washing clothes, ironing, stitching, cutting, drafting, bed making, storing items and performing kitchen activities specially cooking, chopping, kneading, rolling dough, beating mixing, grinding and washing utensils, the anthropometric dimensions and suitability of housewives are grossly neglected. Oberoi et al. (2004) conducted a study on ergonomically sound kitchen plan for rural women. The result of the study showed that kitchen designs based on the anthropometric and reach measurements of the women were very effective in reducing the ergonomic cost of kitchen work. The ergonomic cost of work in the ergonomically sound kitchen was reduced up to 47-50 per cent and with the organized layout of the kitchen the ergonomic cost of work further reduced upto 7-22 per cent. Chaudhary (2004)

conducted a research on standardization of workstation based on ergonomic evaluation of existing kitchens and training. She found that the height of the top shelf was not within the maximum reach of the user. Approximately 27.33 per cent respondents have to raise their heels to reach the top shelf and sometimes they have to use *Patra* or stool to store items. Length of the work center is short and sometime high. Need was therefore felt to formulate optimal space requirements to perform these most commonly and routinely occurring household tasks based on length and breadth dimensions and reaches of the workers body which in case of Indian women would be certainly different than women from west due to racial differences. Recommendations can thus be made for short, medium height category users so that optimum level of work environment achieved which would be least fatiguing to body and produce maximum work output. Present study was thus planned with following specific objectives:

1. To gather anthropometric measurements (length and breadth dimensions and body reaches) of Punjabi women of short, medium and tall height category.
2. To recommend space allowances for selected household activities on the basis of anthropometric measurements of selected women.

METHODOLOGY

Study was conducted in Ludhiana city in 2005. A total sample of 240 females was selected from two approved and two unapproved localities of the city based on the reference height (153 cms) of Indian women. Three height categories were formulated: short (143- 151 cms), medium (151- 159 cms) and tall height (159- 167 cms). Twenty respondents from each height category were selected from each selected colony, having similar weight and body stature and living in approximately same sized houses. Based on the previous literature, all workspaces required for commonly performed household activities (kitchen, bed making, dining, cleaning and clothing care related) were selected.

A record schedule was prepared to note down anthropometric measurements of selected respondents. Anthrop meter was used to record both structural and functional anthropometric data of selected subjects. Based on this data of selected women, the allowances of all workspaces for selected household activities were formulated for each respondent separately. To analyze the data, means and standard deviations were worked out.

RESULTS AND DISCUSSIONS

Anthropometric measurements needed for working out space allowances (length and breadth dimensions; and reach measurements) are being presented and discussed from Table 1- 3.

Length Dimensions

Average length dimensions (Buttock-knee, buttock-popliteal, total arm length, hand length, fore arm length and foot length) of all selected height category users are shown in Table 1. It is evident from table that the mean buttock-knee and buttock-popliteal lengths (in sitting position) were higher in all height categories users from approved locality as shown by the higher values of buttock-knee length (54.88, 53.73 and 49.78 cms respectively) and buttock-popliteal length (49.5, 47.9 and 44.85 cms respectively). Corresponding to this study, Bhalla (1997) found buttock-knee length to be 46.97 cms of elderly females with standard deviation of 7.92 Buttock-knee length is required for designing space around dining table and depth of the seat. Buttock-popliteal length is also required for designing of seat depth.

The same trend was seen in case of the buttock-knee and buttock-popliteal length in squatting position as seen in data presented in Table 1 shows buttock-knee length to be higher i.e. 53.77, 51.97 and 49.97 cms; and buttock-popliteal length also to be more i.e. 48.9, 46.27 and 44.55 cms for tall, medium and short height categories users (of approved locality).

It was also observed that the mean values of arm, hand and fore arm length were higher in case of tall and short height categories users from unapproved locality. Higher values of total arm length (66.57 and 64.2 cms), hand length (19.9

Table 1: Length measurements (cms) of respondents from selected height categories

Length measurements	Tall			Medium			Short		
	AL	UAL	Total	AL	UAL	Total	AL	UAL	Total
	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Buttock knee (Sitting)	54.88 ±3.45	54.73 ±3.4	54.8 ±3.43	53.73 ±2.83	53.45 ±3.13	53.58 ±2.98	49.78 ±2.7	49.18 ±2.33	49.48 ±2.53
Buttock popliteal (Sitting)	49.5 ±3.3	48.78 ±3.43	49.13 ±3.35	47.9 ±3.08	46.73 ±2.58	47.3 ±2.83	44.85 ±2.58	44.13 ±2.38	44.48 ±2.48
Total arm length	63.18 ±2.88	66.58 ±3.78	64.88 ±3.33	64.6 ±2.78	63.18 ±2.93	63.88 ±2.85	63.18 ±2.88	64.2 ±3.08	63.68 ±2.98
Hand length	19.8 ±2.0	19.9 ±2.45	19.85 ±2.23	16.08 ±2.7	15.8 ±2.0	15.93 ±2.35	14.6 ±2.3	14.5 ±3.03	14.65 ±2.68
Fore arm length	38.18 ±2.13	40.5 ±2.33	39.33 ±2.23	39.38 ±1.98	38.18 ±2.13	38.78 ±2.05	36.2 ±2.23	36.78 ±2.45	36.48 ±2.35
Buttock knee (Squatting)	53.78 ±3.15	53.08 ±3.65	53.43 ±3.4	51.98 ±2.35	51.65 ±3.0	51.8 ±2.68	49.98 ±2.7	49.95 ±2.83	49.95 ±2.78
Buttock popliteal (Squatting)	48.9 ±3.02	47.23 ±3.28	48.05 ±3.15	46.28 ±2.68	46.0 ±2.85	46.13 ±2.78	44.55 ±2.58	44.38 ±2.43	44.45 ±2.5
Foot length	21.35 ±1.78	22.13 ±1.58	22.4 ±1.68	21.18 ±1.45	20.63 ±1.95	20.9 ±1.7	19.03 ±1.83	18.63 ±1.68	18.83 ±1.75

AL-Approved locality; UAL-Unapproved locality

and 14.72 cms) and fore arm length (40.5 and 36.77 cms) for tall and short height categories users supports this claim. Fore arm length is important for designing of width and depth of working centers. Hsiao *et al* (2000) found that female protective service officers had significantly greater upper arm length, but female manufacturing worker showed short upper arm. This indicates that the body sizes and shapes of some occupational group are quite different. Mean foot length was maximum in case of tall height category users of unapproved locality (22.12 cms). It is required for designing of foot rest under tables and paddles of sewing machine.

Breadth Dimensions

The mean breadth measurements are presented in Table 2 which included shoulder breadth, hip breadth, elbow to elbow, hand breadth at thumb, knee to knee breadth and foot breadth. Data in the table revealed that shoulder breadth of tall and medium height category users from unapproved locality was higher in both sitting and standing position; as seen by the higher values of shoulder breadth (39.07 and 38.65 cms) in standing and (37.82 and 37.45 cms) in sitting positions for tall and medium height categories users. Shoulder breadth is required for designing width of doors and passage and chair's backrest width. Haslegrave (1980) indicated that among men or women in the highest deciles of weight, a group of horizontal

dimensions (chest breadth, seat breadth, chest-depth and thigh depth) have an increased correlation with their weight. Present investigation also had some indication of having correlation in weight and breath measurements.

It also indicated that hip breadth of tall and medium height category users from approved locality was higher in both standing i.e. 31.47 and 30.85 cms and sitting positions i.e. 32.32 and 31.42 cms. Hip breadth (in standing position) is required for designing widths of doors and passages. Hip breadth (in sitting position) is required for designing of seat breadth. However, the elbow to elbow breadth (47.97 cms) was observed to be maximum in medium height category users of unapproved locality. This measurement is required to design space around kitchen worktops.

Data also revealed that hand breadth at thumb and foot breadth were higher in all the height category users of unapproved locality; as shown by the higher values of hand breadth at thumb i.e. 8.07, 7.65 and 7.52 cms respectively, and foot breadth i.e. 9.12, 9.0 and 8.35 cms respectively for tall, medium and short height categories users. Hand breadth at thumb measurement is required for designing of taps, grab handles, door-handles, handles of various equipment like mixer, jars etc. Foot breadth is required for designing of foot rest under the tables, foot rest of wheel chair and paddles of sewing machine. Bhalla (1997) also found the foot breadth of elderly females to be 9.25 cms, which

Table 2: Breadth measurements (cms) of respondents from selected height categories

Breadth measurements	Tall			Medium			Short		
	AL	UAL	Total	AL	UAL	Total	AL	UAL	Total
	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Shoulder breadth (standing)	38.38	39.08	38.75	38.33	38.65	38.47	37.63	37.53	37.58
	±2.4	±2.08	±2.25	±2.13	±2.03	±2.08	±2.55	±2.50	±2.53
Hip breadth (standing)	31.48	30.45	30.95	30.85	30.43	30.63	30.35	30.63	30.48
	±4.48	±2.93	±3.7	±4.45	±2.63	±3.55	±3.35	±3.58	±3.48
Shoulder breadth (sitting)	36.95	37.83	37.37	37.15	37.45	37.3	36.83	36.32	36.58
	±1.87	±1.9	±1.9	±1.88	±1.82	±1.85	±1.58	±1.47	±1.53
Hip breadth (sitting)	32.32	30.63	31.47	31.43	30.38	30.9	30.58	30.63	30.6
	±5.60	±8.2	±6.9	±4.25	±2.88	±3.58	±4.3	±4.33	±4.33
Elbow to elbow	47.00	46.6	46.8	46.55	47.98	47.25	43.95	44.00	43.98
	±5.00	±4.55	±4.77	±6.23	±3.93	±5.08	±4.5	±4.55	±4.53
Hand breadth at thumb	7.85	8.08	7.95	7.57	7.65	7.6	7.43	7.53	7.48
	±0.55	±0.63	±0.6	±0.3	±0.43	±0.38	±0.95	±1.13	±1.05
Knee to knee breadth (sitting)	20.63	19.50	20.05	20.1	19.85	19.98	18.48	18.75	18.60
	±4.50	±2.87	±3.83	±3.85	±4.1	±3.98	±4.57	±4.87	±4.73
Foot breadth (sitting)	8.87	9.13	9.00	8.67	9.0	8.83	8.37	8.4	8.38
	±0.83	±0.73	±0.77	±0.8	±0.93	±0.85	±0.98	±0.98	±0.98

AL-Approved locality; UAL-Unapproved locality

was however, little higher than data reported in the present study. It can be clearly seen in table that knee to knee breadth was higher (20.62 and 20.1 cms) in tall and medium height category users of approved locality. Thus it can be highlighted that hip breadth, elbow to elbow and knee to knee breadth measurements of any user are irrespective of stature.

Reach Measurements

Reach measurements which included vertical reach, horizontal forward reach, maximum vertical reach, maximum horizontal forward reach, side reach and normal reach, are shown in Table 3. Data in the table disclosed that the average vertical reach of the users of all height categories varied from 180.9 to 161.32 cms. Tall height category users from unapproved locality had higher vertical reach (183.55 cms). This measurement is required for designing height of storage shelves.

The same trend was seen in case of their horizontal forward reach which was maximum (67.12 cms) in case of tall height category users. Horizontal forward reach is required for designing space for kitchen activities, maximum depth of storage shelves, space on right and left side of sink and area for washing clothes ironing, stitching and cutting and drafting.

It was observed that mean maximum vertical and horizontal forward reaches were higher (190.0 and 74.37 cms) in case of tall height category. Maximum reaches are required for designing of maximum height of storage shelves, clothes line and maximum depth of kitchen work tops and

width of table (for cutting and drafting). Side reach of tall height category users from unapproved locality was highest i.e. 71.77 cms. Table also indicated that normal reach was higher (105.85 and 98.62 cms) in tall and medium height category of approved locality. It is required for designing of minimum height of storage shelves and socket outlets.

Formulation of Dimensions of Workspaces

Criteria for Formulating Dimensions of Equipment, Furniture and Workplaces:

Formulas given by NIOSH (National Institute of Occupational Safety and Health), Robert (1960) and recommendations given by National Building Code of India were used as a criteria to recommend heights of selected work areas according to anthropometric dimensions of selected height category users. These were: space for kitchen activities: (elbow to elbow + 10 cms allowance) x horizontal forward reach; sink width: 50 cms; sink depth: 15-20 cms; space on right side of sink: horizontal forward reach of right hand; space on left side of sink: horizontal forward reach of left hand; deepest dimension of storage shelf: horizontal forward reach + 10 cms; space in front of refrigerator door and washing machine: stooping length; space for bed making: kneeling length + 20 cms; space for serving seated person: stooping length; space around dining table: buttock knee length + 24 cms; space around seated person: length of body above seat + 20 cms; cleaning under bed: prone height + 10 cms; space for cleaning furniture: kneeling length; space for cleaning under dining table:

Table 3: Reach measurements (cms) of respondents from selected height categories

Reach measurements	Tall			Medium			Short		
	AL	UAL	Total	AL	UAL	Total	AL	UAL	Total
	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Vertical reach	180.9	183.0	182.25	178.92	176.07	177.5	161.4	161.32	161.35
	±7.0	±4.97	±6.35	±5.45	±4.07	±9.77	±10.05	±10.00	±10.02
Horizontal forward reach	66.7	66.9	66.9	65.0	63.85	64.25	61.82	61.4	61.5
	±2.27	±2.55	±2.42	±2.32	±2.4	±2.37	±2.75	±2.40	±2.57
Max. vertical reach	189.1	191.5	190.3	186.65	184.22	185.42	169.55	167.62	168.57
	±7.82	±5.55	±6.7	±5.00	±4.32	±4.72	±10.05	±10.72	±10.15
Max horizontal forward reach	74.15	74.0	74.25	72.75	71.92	72.32	68.12	69.17	68.65
	±2.22	±2.0	±2.12	±2.30	±2.37	±2.35	±2.65	±2.97	±0.32
Side reach	71.52	71.77	71.65	66.42	65.65	66.02	64.4	63.75	64.07
	±2.22	±2.5	±2.37	±2.10	±2.77	±2.45	±2.62	±2.55	±2.6
Normal reach	105.85	102.0	103.92	98.62	97.72	98.17	91.5	93.07	92.27
	±4.42	±4.05	±1.75	±1.47	±1.80	±1.65	±1.35	±1.85	±1.6

AL-Approved locality; UAL-Unapproved locality

squatting on hunches + 20 cms; space for ironing, stitching: horizontal forward reach x normal reach of working hand; space for washing clothes, cutting and drafting: horizontal forward reach x (side reach of right hand+ side reach of left hand + shoulder width); space for opening drawer: 120 cms; width of table: 2 x horizontal forward reach; depth of table/board: horizontal forward reach.

Recommendations given in Table 4 clearly shows that maximum space (approximately .45 – .38 sq. mts) was required for ironing, stitching, cutting, drafting and washing clothes followed by kitchen activities viz: cooking, chopping, kneading, beating, mixing, dough rolling and grinding; which ranged from approximately .32 – .38 sq. mts. Space requirement increased with the height of respondents since elbow to elbow width hand reaches increase with stature thus leading to more space requirement. Similar trend was evident while determining height of clothes line (168.22-190.02 cms) and space in front of washing machine and refrigerator; and for serving seated person (76.37-101.5 cms).

Less variation (of 12.5-15 cms) in recommended range can be seen in Table 4 for determining depth of work shelf (60.12-76.25 cms) and cleaning under dining table (50.45-63.22 cms). however space requirement recommendation

ranged between 5 - 7.5 cms only while designing sink sides (60.5-67.0 cms); width and depth of table for cutting and drafting; space for bed making (89.47-97.25 cms); around dining table (73.5-78.67 cms); around seated person (89.57-94.62 cms) and for cleaning furniture (67.47-76.7 cms).

Data in table revealed that recommended space for cleaning under bed had only 2.5 cms range (49.22-49.4 cms). It may be due to the fact that for determining this space one requires prone height which is irrespective of stature, hence minimum difference in specification for different height category users.

CONCLUSIONS

It can be concluded from the present study that for different height category users, work space requirement also differs. Most prominent and determinant measurements are: elbow to elbow width, horizontal, vertical, side and normal hand (left and right) reaches, stooping length, kneeling length, buttock knee length, length of body above seat, prone height and squatting on haunches height. Minimum allowance of 10 cms over and above the body dimension is required for safety and work efficiency in standing posture. However for activities which are performed in stooping and bending position, it

Table 4: Recommended space allowances of selected workspaces for all height category users

<i>Space requirements</i>	<i>Mean values (cms) for selected height categories</i>			
	<i>Tall users</i>	<i>Medium height users</i>	<i>Short users</i>	<i>Range of space</i>
Cooking, chopping, Kneading, beating, mixing, dough rolling, grinding centers	.38	.37	.33	.32 -.38
Sink width	50.00	50.00	50.00	-
Sink depth	17.5	17.5	17.5	-
Right of sink	66.8	64.62	60.95	60.5-67.0
Left of sink	66.72	63.77	61.25	60.8 -66.97
Depth of self	30.49	23.79	24.17	24.05-30.50
In front of refrigerator & washing machine	38.66	36.73	30.80	30.55-40.96
Bed making	38.79	36.78	35.83	35.79-38.90
Serving seated person	38.66	36.73	30.80	30.55-40.96
Around dining table	31.30	31.06	29.37	29.24-31.47
Around seated person	37.77	36.84	35.90	35.83-37.85
Cleaning under bed	19.48	22.45	20.21	19.69-19.76
Cleaning under dining table	25.03	25.19	20.56	20.18-25.29
Cleaning furniture	30.59	31.83	27.83	27.79-30.68
Ironing and stitching	716.15	664.12	611.58	611.29-720.90
Cutting, drafting & washing clothes	733.76	664.59	611.49	611.40-719.95
Opening drawers	48.00	48.00	48.00	-
Width of cutting drafting table	59.40	58.01	56.23	56.11-59.50
Depth of cutting drafting table	26.70	25.35	24.79	24.52-26.80
Clothes line	75.53	73.95	67.31	67.29-76.01

Figures in italics are area in square cms

should be increased up to 20-25 cms for balance of body and ease of movements.

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