

## RESULTS AND DISCUSSION

## CHAPTER IV.

### RESULTS AND DISCUSSION

Results of the investigation pertaining to various objectives are presented in this chapter.

Section-1. Background information

Section-2. Anthropometric and Reach measurements

Section-3. Housing Data

Section-4. Existing kitchen condition

Section-5. Evolved standards and suggested design of kitchen layout

Section-6. Testing of Hypotheses

#### SECTION-1

#### BACKGROUND INFORMATION

The background information of the selected sample population is a basic requirement as it provides the descriptive information which helps in interpretation of some of the results of this study. The findings pertaining to this section are as follows :

TABLE : 7. The Personal Characteristics of the Respondents.

Personal Characteristics	N=526	
	Frequency	Percentage
<b>AGE (in years)</b>		
18-24	145	27.57
25-34	144	27.38
35-44	153	29.07
45 and above	84	15.97
<b>MARITAL STATUS</b>		
Married	384	73.00
Unmarried	134	25.48
Widow	8	01.52
<b>RELIGION</b>		
Hindu	514	97.72
Muslim	5	00.95
Christian	1	00.19
Sikh	1	00.19
Jain	5	00.95
<b>CASTE</b>		
General caste	501	95.25
Scheduled caste	6	01.14
Scheduled tribe	2	00.38
Backward tribe	3	00.57
Backward caste	14	02.66
<b>NUMBER OF CHILDREN</b>		
No children	155	29.47
One child	58	11.03
Two to four children	298	56.65
Five to seven children	15	02.85

The personal characteristics of the sample namely, age, marital status, religion, caste and number of children were assessed (Table-7). Not much variation was found in the

percentages of respondents belonging to the different age groups. About 27 per cent of the respondents were in the age group of less than 25 years and 25 to 34 years, whereas 29 per cent of them were in the age group of 35 to 44 years. Thus, it indicates that majority of the sample were young and in early middle age.

Majority of the sample were married and only 25 per cent were unmarried.

About 97 per cent of the sample were Hindus and the remaining belonged to Muslim, Jain, Christian and Sikh religions.

General caste category took the upper hand in the present survey by revealing 95 per cent. This group consisted of all forward caste population indentified by the government of Karnataka, namely, Brahmin, Lingayat, Gowd Saraswath, Marathas, etc. However, Brahmin and Lingayat caste dominated among the selected sample.

Regarding the number of children of the respondents under the study, about 29 per cent were not having issues, while 56 per cent reported that they were having two to four children. Percentage of families having one child or more than five children was negligible.

TABLE 8. Family characteristics of the Selected Respondents.

Family Characteristics	N=526	
	Frequency	Percentage
<b>NUMBER OF FEMALE MEMBERS IN THE AGE GROUP OF 18 TO 50 YEARS IN THE HOUSEHOLDS</b>		
One	352	66.92
Two	115	21.86
Three and above	59	11.22
<b>TOTAL MONTHLY INCOME (in rupees)</b>		
Upto 4000.00	189	35.93
4001.00 to 7000.00	192	36.50
7001.00 to 10000.00	80	15.21
10001.00 and above	11	02.09
Reported response*	54	10.27
<b>FOOD HABIT</b>		
Vegetarian	465	88.40
Non-vegetarian	61	11.60
<b>FREQUENCY OF NON-VEG CONSUMPTION (N=61)</b>		
Once in a week	27	44.27
Twice in a week	9	14.75
Thrice in a week	4	6.56
Once in a month	13	21.31
Twice in a month	8	13.11
<b>TYPE OF FAMILY</b>		
Nuclear	373	70.91
Joint	153	29.09

\* - Is applicable to the sample where there was more than one person from the same household.

In the 67 per cent of households number of female members available in the age group of 18 to 50 years was only one and 21 per cent had 2 persons in a household (Table-8).

As regards the total monthly income of the selected respondent households, the majority belonged to the first three categories of income range. Thirty five and 36 per cent of the families belonged to the lower limit of middle income group i.e., upto Rs. 4000 and the next range of Rs. 4001 to Rs. 7000, respectively. However, in 15 per cent of households the monthly income was Rs. 7001 to Rs. 10000.

A high percentage (about 88 per cent) of the selected women reported that their families consumed only vegetarian food. Obviously the remaining 12 per cent of the households had non-vegetarian food habit. Among these 44 per cent reported of consuming non vegetarian food once in a week, while for 21 per cent of families the frequency was stretched to once in a month.

Nuclear family was predominant among the selected sample.

TABLE : 9. Educational Background of the Respondents and Head of the Family.

Educational background	N=526	
	Frequency	Percentage
<b>RESPONDENTS</b>		
Upto Pre-University	277	52.67
Diploma	12	02.28
Graduation	213	40.49
Technical graduation	6	01.14
Post graduation	18	03.42
<b>HEAD OF THE FAMILY</b>		
Upto Pre-University	81	15.40
Diploma	24	04.56
Graduation	192	36.51
Technical graduation	102	19.39
Post graduation	127	24.14

Fifty two per cent of women studied upto Pre-university and 40 per cent of the sample were graduates (Table-9).

With regard to educational background of the respondents' husband or head of the family, nearly one-third of them (36 per cent) were graduates. This was followed by post-graduation (24 per cent) and technical graduation (19 per cent). It is clear from the data that respondents and spouses or heads were well educated.

TABLE : 10. Occupation of Respondents and their Spouses or Head of the Family.

		N=526	
Occupation		Frequency	Percentage
<b>RESPONDENTS</b>			
<b>HOMEMAKERS :</b>			
	Employed	26	04.94
	Non-employed	380	72.24
<b>Girls :</b>	Studying	75	14.26
	Education completed	45	8.56
<b>HUSBANDS or HEAD</b>			
	Agriculture	14	02.66
	Business	76	14.45
	Professional	77	14.64
	Service	270	51.33
	Pensioner	33	06.27
	Repeated response*	56	10.65

\* - Is applicable to the sample where there was more than one person from the same household.

The employment status of the women under the present study showed that 72 per cent were non-employed housewives and only 4 per cent were gainfully employed outside the home

(Table-10). The sample also included 14 per cent of girls studying in the college and 8 per cent of girls who had completed their education and were staying at home and most of them were unmarried.

Fifty one per cent of respondents' spouses or head of the family were engaged in service i.e., in Government offices, private organizations, factories, banks, etc. They were mainly clerks, officers, administrators etc., and 14 per cent each were in business and in professional jobs such as practising medicine, law, auditing etc.

TABLE : 11. Place of Origin of Respondents.

Place of Origin	N=526	
	Frequency	Percentage
City	333	63.31
Town	121	23.00
Village	72	13.69
STATES		
Karnataka	492	93.54
Maharashtra	20	03.80
Andra Pradesh	7	01.33
Tamilnadu	3	00.57
Goa	1	00.19
Punjab	1	00.19
Delhi	1	00.19
West Bengal	1	00.19

The place of origin of the selected sample women showed that about 63 per cent of them were from city and 23 per cent belonged to the town (Table-11). Majority of the respondents belonged to Karnataka state, among them more than 50 per cent were from Northern Karnataka. The rest of the respondents (7 per cent) were from Maharashtra, Andra pradesh, Tamilnadu and other states.

## SECTION-2

### ANTHROPOMETRIC AND REACH MEASUREMENTS

#### 1. ANTHROPOMETRIC MEASUREMENTS :

Knowledge of anthropometric dimensions is an important requisite for the designing of work space, work place and equipment. Anthropometry of standing and sitting position of 526 women, aged between 18 to 50 years was studied. Important body measurements for reaches were investigated. The detailed analysis of anthropometric measurements is presented in this section.

The mean stature of Northern Karnataka women was found to be 152.33 cm (Table-12). The variation among the sample with regard to height, arm length, elbow height and eye height was small as coefficient of variation (C.V.) was found to be 0.040 to 0.045. However, the examination of minimum and maximum values for each dimension revealed a wide range. The C.V. was ranging from 0.055cm to 0.123 cm, indicating a sizeable difference among 526 women for other linear (Standing) body dimensions.

Coefficient of variation for all sitting heights ranged from 0.050 to 0.090 revealing obvious differences among the sample group when compared to standing heights.

Comparatively the variation among the selected respondents' circumference measurements was high. The C.V. for all girth measurements was found to be above 0.093 and within 0.142 the variability for waist measurement was very high (0.142) when compared to other girths.

TABLE : 12. Statistical Analysis of Anthropometric Measurements [N=526].

Anthropometric measurements (cm)	(cm)		Mean	Sd	Skewness	C.V.
	Minimum	Maximum				
<b>Standing heights</b>						
Stature	132.40	189.00	152.33	6.19	0.48	0.040
Total arm span	135.00	179.00	158.67	7.18	-0.07	0.045
Right arm length	32.30	81.00	68.21	3.86	-1.29	0.056
Elbow height	83.20	110.00	93.89	4.21	0.35	0.044
Upperarm length (Right)	19.50	39.00	29.85	2.11	0.09	0.070
Forearm length (Right)	18.20	42.00	22.98	2.83	3.71	0.123
Hand length (Right)	13.60	20.00	17.61	1.22	-0.05	0.069
Leg height (Right)	13.30	103.00	87.14	5.92	-4.05	0.067
Lower leg height (Right)	13.30	52.00	43.73	2.85	-2.45	0.065
Eye height	123.30	163.00	141.39	5.76	0.09	0.040
Functional reach-1	55.00	77.00	66.35	3.66	0.00	0.055
Functional reach-2	54.00	76.00	65.36	3.65	0.01	0.055
<b>Sitting heights</b>						
Elbow height	52.50	97.00	66.19	4.74	0.89	0.071
Sitting height	48.70	117.00	76.80	4.03	1.19	0.052
Eye height	90.00	177.00	113.66	6.44	2.77	0.056
Stool height	14.70	79.00	46.21	4.18	0.30	0.090
<b>Circumference measurements (standing)</b>						
Bust	61.00	112.00	81.95	9.01	0.22	0.109
Upper arm (Right)	16.00	34.00	24.87	3.07	0.09	0.123
Forearm (Right)	16.00	33.00	22.50	2.10	0.32	0.093
Waist	21.00	101.00	70.91	10.10	-0.19	0.142
Abdomen	58.00	130.00	86.53	11.59	0.23	0.133
Hip	67.00	139.00	94.58	10.39	0.26	0.109

Skewness of the distribution :

Further, the measure of the divergence from normality indicated the nature of distribution whether positively or negatively skewed. For many linear (both standing and sitting) and circumferential measurements, the skewness was positive i.e., to the right, indicating that more number of respondents lie under the area less than mean. For arm span, arm length, hand length, leg height, lower leg height and for waist, the skewness was negative. Thus, more number of women had length, girth more than mean. For functional reach, the skewness was zero, thereby indicating that the functional reach measurement distribution was normal. For majority of the body dimensions the skewness was found to be less than  $\pm 1$ .

Since data revealed a wide variation for different anthropometric measurements it was felt that the mean values of measurements may not be ideal in developing standards for designing. Hence, further analysis of distribution of anthropometric measurements for 5th, 50th and 95th percentile groups, was carried out and is presented in Table-13 and Fig. 9 and 10.

Thus, it could be concluded that the wide variation was observed for various anthropometric characteristics and this could be attributed to the heterogeneous nature of the sample because of age (18-50 years), marital status, food habit etc.

TABLE : 13. Percentile Values of Anthropometric Measurements  
[N=526].

		Anthropometric Measurements (cm)	Percentile values		
			5th	50th	95th
Standing heights	1	Stature	137.54	147.85	152.85
	2	Total arm span	144.61	156.75	169.25
	3	Right arm length	57.27	62.84	73.94
	4	Elbow height	87.20	93.90	101.67
	5	Upper arm length (Right)	22.52	28.39	31.46
	6	Forearm length (Right)	16.03	20.75	25.34
	7	Hand length (Right)	15.63	17.67	19.88
	8	Leg height (Right)	66.11	81.23	93.26
	9	Lower leg height (Right)	29.66	41.03	47.38
	10	Eye height	130.36	139.17	149.77
	11	Functional reach-1	59.02	61.10	72.15
	12	Functional reach-2	57.02	64.16	70.63
Sitting heights	1	Elbow height	50.77	61.68	67.23
	2	Sitting height	62.03	73.54	79.49
	3	Eye height	97.40	109.45	120.60
	4	Stool height	29.33	43.14	48.56
Circum- ferences standing	1	Bust	60.88	77.61	86.79
	2	Upper arm (Right)	20.20	23.40	29.26
	3	Forearm (Right)	17.01	20.74	25.54
	4	Waist	49.49	65.85	84.04
	5	Abdomen	63.71	81.19	101.87
	6	Hip	73.00	90.07	108.80

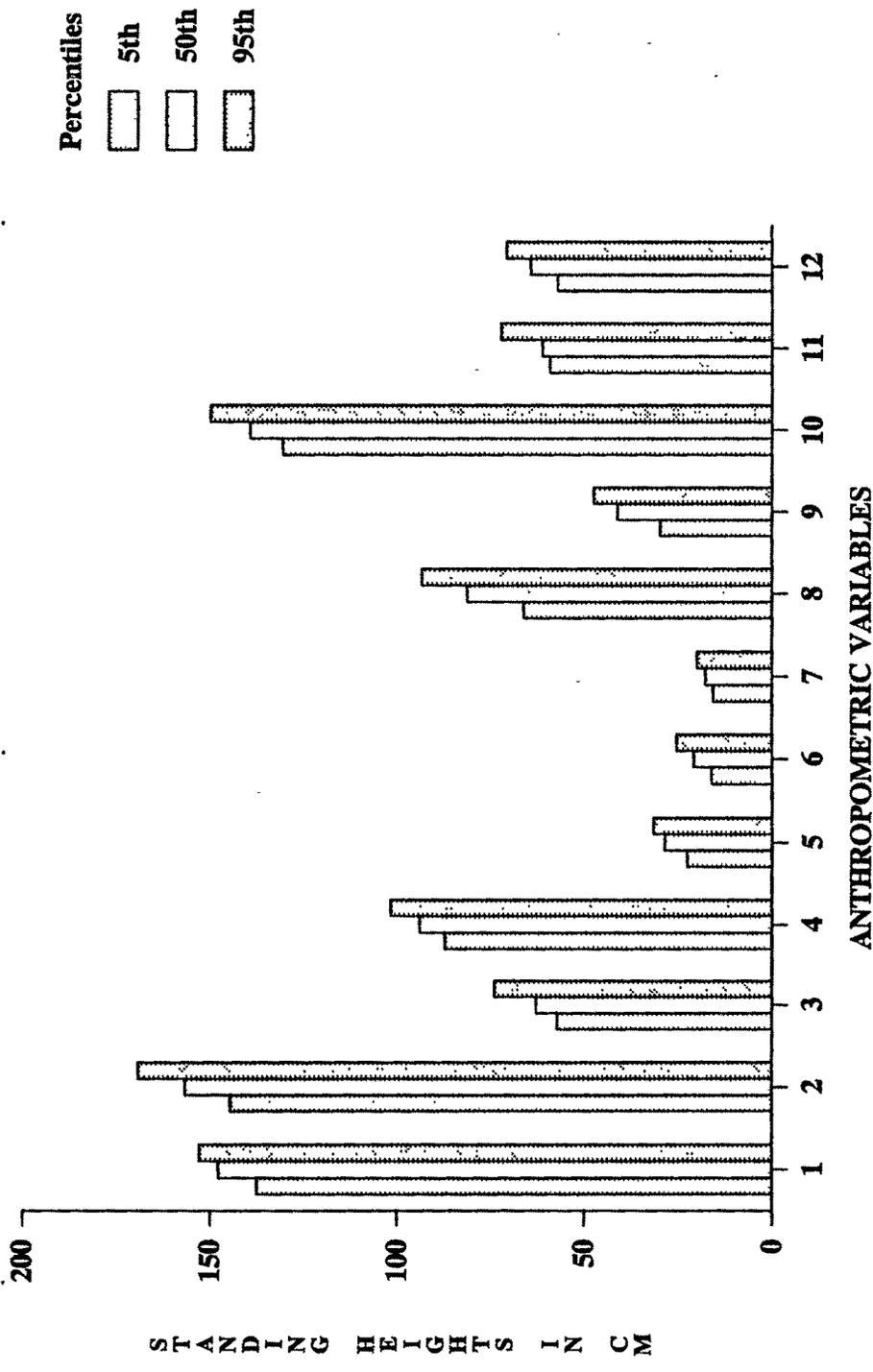
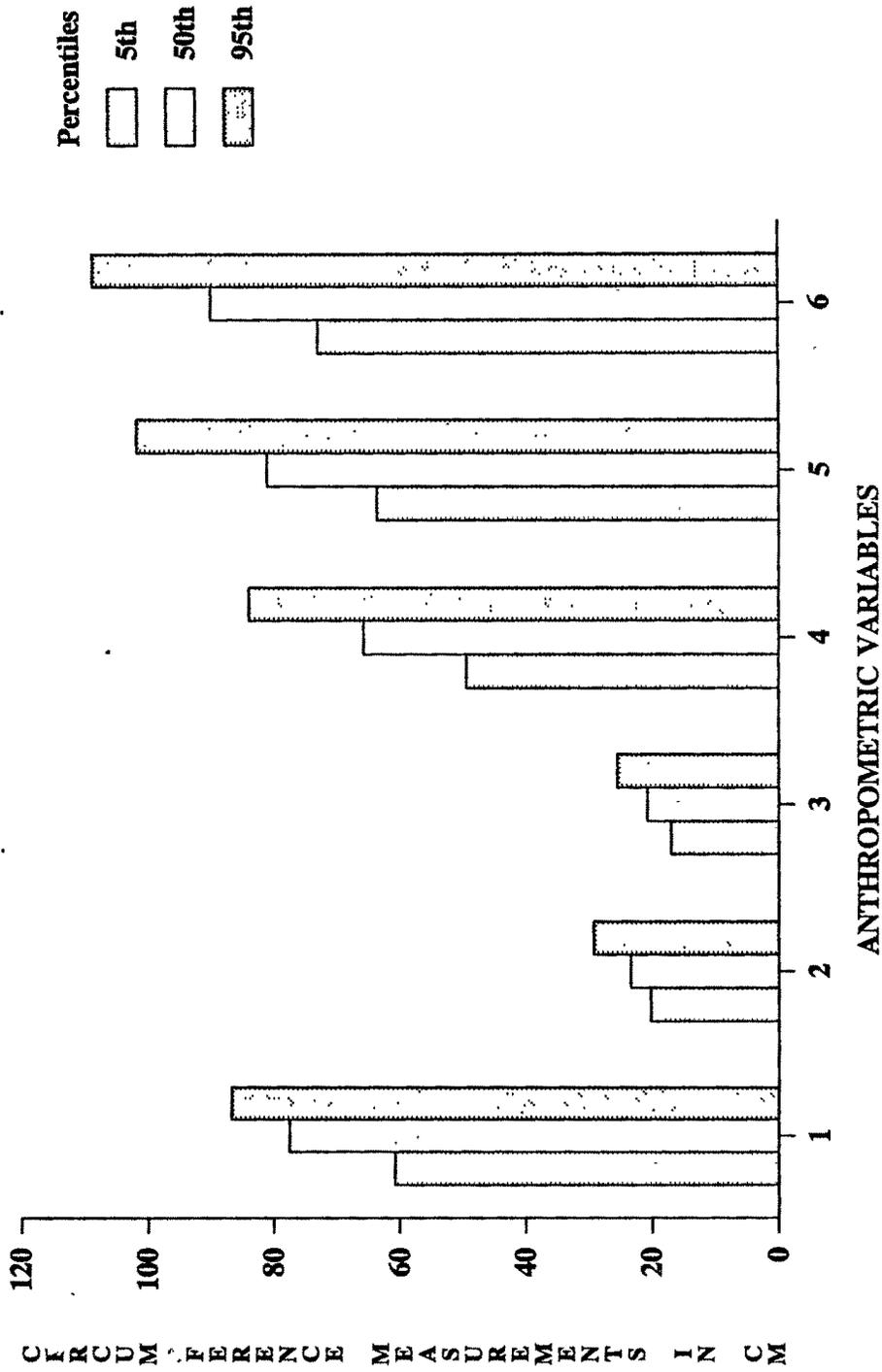


Fig.9. PERCENTILE VALUES OF STANDING HEIGHTS



**Fig. 10. PERCENTILE VALUES OF CIRCUMFERENCE MEASUREMENTS**

## 2. MEASUREMENT OF REACHES

The vertical and horizontal distances that people can reach are of considerable importance. The measurements of reaches of 526 women are reported as follows.

### VERTICAL REACHES :

Vertical reaches of an individual are very important so as to find out one's comfortable working area i.e., both maximum and normal. When an individual stands close to the wall, the maximum two handed reach is always more than while standing away from the wall. The mean reach when standing close to wall was found to be 186.61 cm (Table-14). As one moves away from the wall the mean reach measurement showed a decrease. Hence while standing 15 cm and 30 cm away from the wall the reach was found 181.23 cm and 175.05 cm respectively.

Examination of upward one hand and two handed reach when standing 15 cm away from wall indicated that the mean upward reach of one hand was higher (183.12 cm) than mean reach for two hands (181.23 cm). The mean downward reach of one hand was 72 cm. The upward and downward reach for one hand is a mirror image for the other hand also.

TABLE : 14. Mean Vertical Reaches of Women (N=526).

Reach Variables	Reach Measurements (cm)			
	Minimum value	Maximum value	Mean	
Max. Vertical two handed reach	Close to the wall	144.00	214.00	186.612
	15 cm away from wall	120.00	212.00	181.238
	30 cm away from wall	97.00	200.00	175.054
One hand reach (Right hand) 15 cm away from wall	Upward reach	126.00	213.00	183.128
	Downward reach	45.00	176.00	72.00
Nor. Vertical two handed reach	15 cm away from wall	87.00	126.00	105.00
	30 cm away from wall	31.00	124.00	104.60

Data analysis for normal vertical two handed reach revealed 105 and 104 cm as mean reaches when standing at 15 cm and 30 cm away from the wall respectively.

Further, percentile distributions of 526 sample for above discussed vertical reaches were worked out with reference to stature (Fig. 11 and 12, Table-65 in Appendix-4).

Relationship of standing heights with vertical reaches :

Relationship of various vertical reaches with selected anthropometric parameters was studied by computing correlation coefficient (Table-15). All the standing heights were positively related at or beyond 0.05 level with maximum

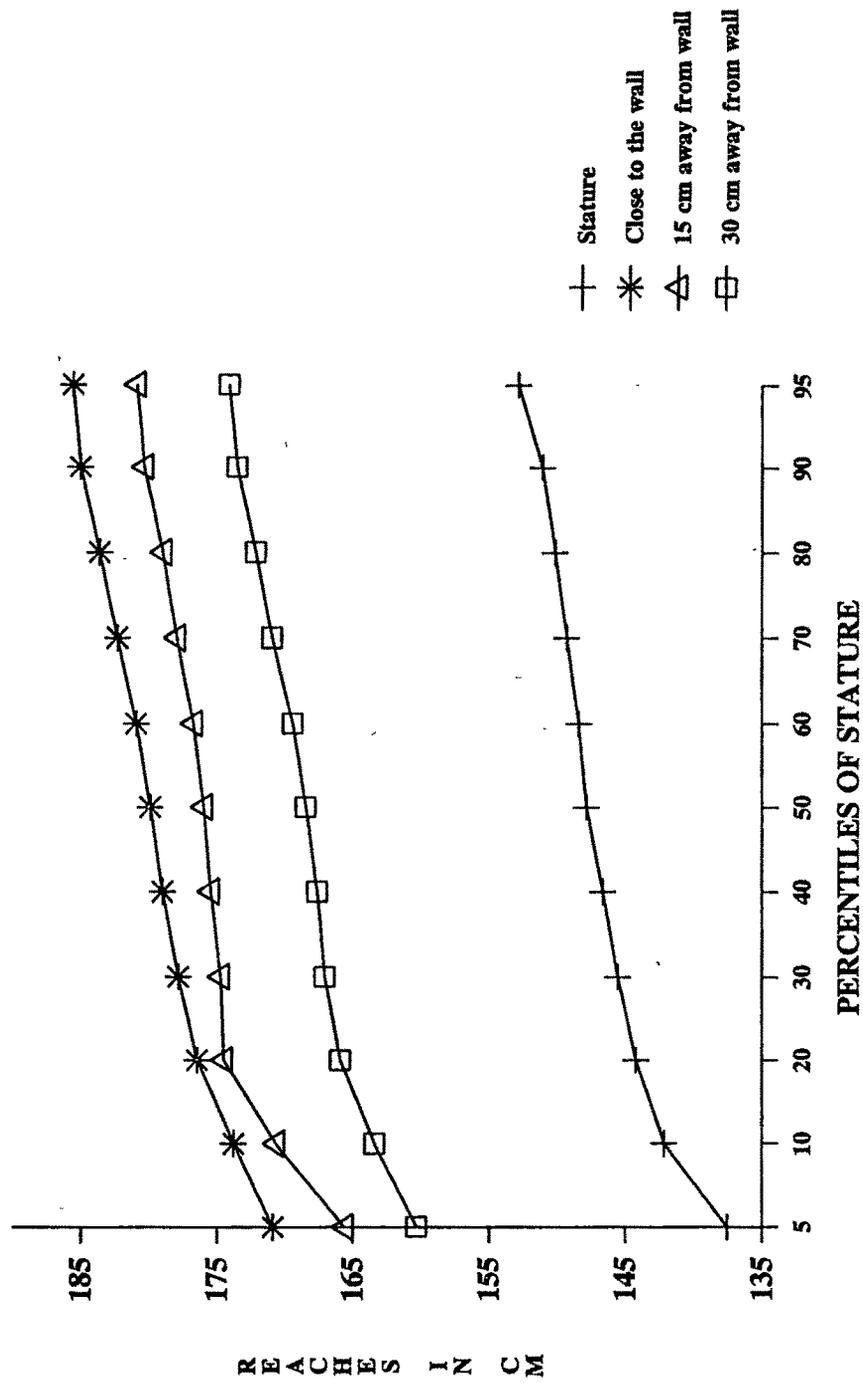


Fig. 11. PERCENTILE DISTRIBUTION OF  
 MAXIMUM VERTICLE TWO HANDED REACHES AT  
 VARIOUS STANDING DISTANCES

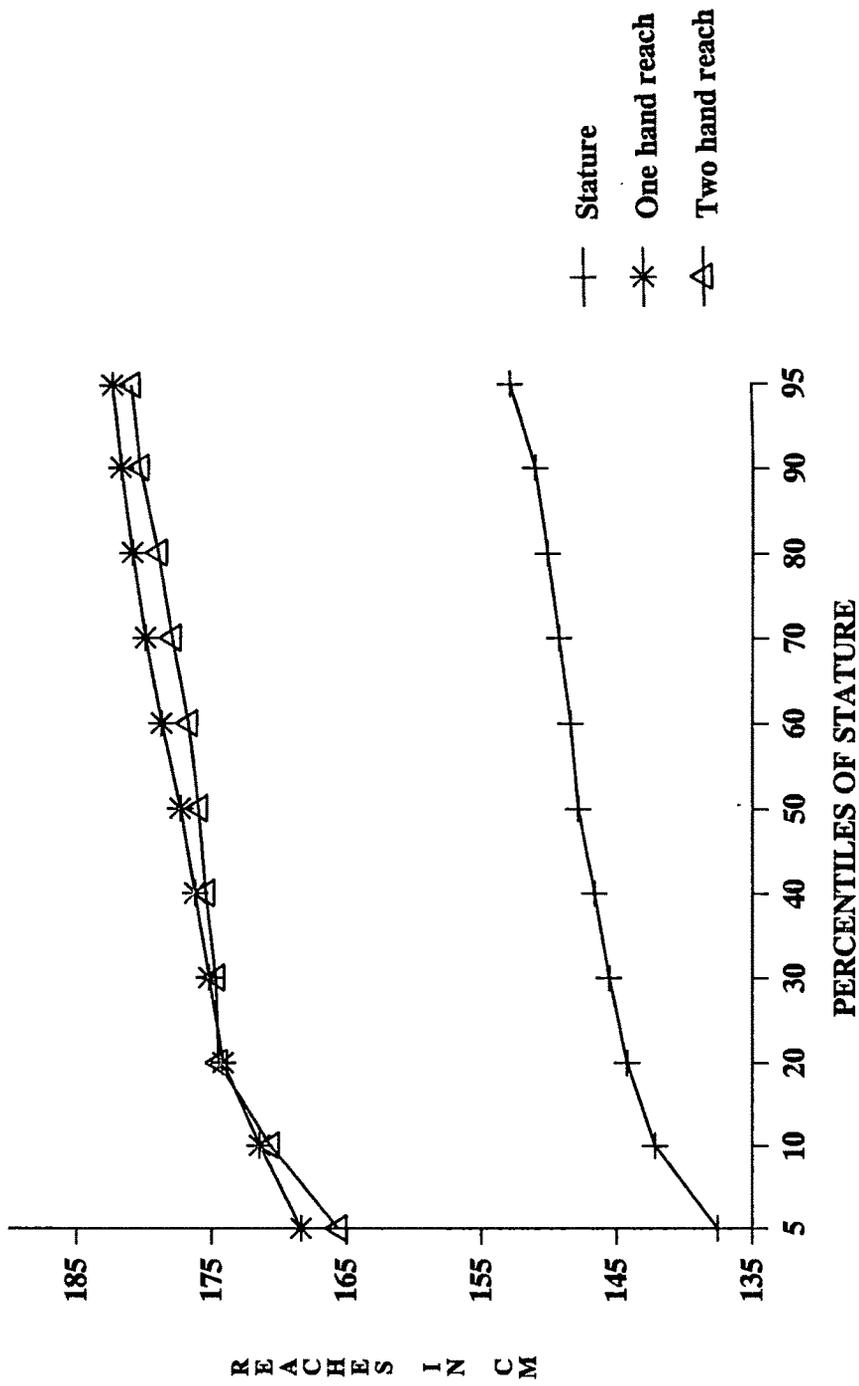


Fig. 12. COMPARISON OF MAXIMUM VERTICLE ONE HAND WITH TWO HANDED REACH STANDING 15 CM AWAY FROM WALL

TABLE : 15. Correlation Coefficient and Percentage Relationship of Anthropometric Variables and Vertical Reaches.

Anthropometric variables	Max. V. two handed reach													
	Close to the wall				15cm away from wall				30cm away from wall					
	r	r <sup>2</sup>	r	r <sup>2</sup>	r	r <sup>2</sup>	r	r <sup>2</sup>	r	r <sup>2</sup>	r	r <sup>2</sup>		
Stature	0.845**	71.40	0.738**	54.46	0.660**	43.56	0.770**	59.29	0.287**	8.24	0.484**	23.43	0.374**	13.99
Arm span	0.823**	67.73	0.724**	52.42	0.654**	42.77	0.765**	58.52	0.169**	2.86	0.437**	19.10	0.309**	15.21
Arm length	0.707**	49.98	0.643**	41.34	0.563**	31.70	0.655**	42.90	0.163**	2.66	0.390**	15.21	0.266**	7.08
Elbow height	0.787**	61.94	0.685**	46.92	0.566**	32.04	0.707**	49.98	0.343**	11.76	0.495**	24.50	0.373**	13.91
Upperarm length	0.596**	35.52	0.510**	26.01	0.490**	24.01	0.507**	25.70	0.097*	0.94	0.268**	7.18	0.240**	5.76
Forearm length	0.355**	12.60	0.327**	10.69	0.287**	8.24	0.215**	4.62	0.088*	0.77	0.181**	3.28	0.366**	13.40
Hand length	0.498**	24.80	0.446**	19.89	0.441**	19.45	0.478**	22.85	0.048 <sup>NS</sup>	0.23	0.230**	5.29	0.166**	2.76
Leg height	0.504**	25.40	0.430**	18.49	0.368**	13.54	0.463**	21.44	0.240**	5.76	0.256**	6.55	0.236**	5.57
Lower leg height	0.593**	35.16	0.509**	25.91	0.472**	22.28	0.543**	29.48	0.140**	1.96	0.341**	11.63	0.231**	5.34
Eye height	0.843**	71.06	0.739**	54.61	0.648**	41.99	0.782**	61.15	0.253**	6.40	0.479**	22.94	0.359**	12.89
Functional reach-1	0.685**	46.92	0.629**	39.56	0.568**	32.60	0.673**	45.29	0.023 <sup>NS</sup>	0.05	0.230**	5.29	0.127**	1.61
Functional reach-2	0.690**	47.61	0.635**	40.32	0.571**	32.60	0.678**	45.97	0.021 <sup>NS</sup>	0.04	0.233**	5.43	0.128**	1.64

Anthropometric variables	Nor. V. two handed reach													
	Close to the wall				15cm away from wall				30cm away from wall					
	r	r <sup>2</sup>	r	r <sup>2</sup>	r	r <sup>2</sup>	r	r <sup>2</sup>	r	r <sup>2</sup>	r	r <sup>2</sup>		
Bust	0.080*	0.64	0.025 <sup>NS</sup>	0.06	0.056 <sup>NS</sup>	0.31	0.041 <sup>NS</sup>	0.17	0.033 <sup>NS</sup>	0.10	0.116**	1.35	0.048 <sup>NS</sup>	0.23
Upperarm	0.070 <sup>NS</sup>	0.49	0.037 <sup>NS</sup>	0.14	0.056 <sup>NS</sup>	0.31	0.011 <sup>NS</sup>	0.01	0.053 <sup>NS</sup>	0.28	0.146**	2.13	0.122**	1.49
Forearm	0.156**	2.43	0.098*	0.96	0.113**	1.28	0.101 <sup>NS</sup>	1.02	0.066 <sup>NS</sup>	0.43	0.173**	2.99	0.125**	1.56
Waist	0.015 <sup>NS</sup>	0.02	-0.028 <sup>NS</sup>	0.08	0.003 <sup>NS</sup>	0.00	-0.023 <sup>NS</sup>	0.05	-0.022 <sup>NS</sup>	0.05	0.056 <sup>NS</sup>	0.31	0.004 <sup>NS</sup>	0.00
Abdomen	0.087*	0.76	0.030 <sup>NS</sup>	0.09	0.090*	0.81	0.046 <sup>NS</sup>	0.16	-0.055 <sup>NS</sup>	0.30	0.078 <sup>NS</sup>	0.61	0.031 <sup>NS</sup>	0.10
Hip	0.112**	1.25	0.057 <sup>NS</sup>	0.32	0.081*	0.66	0.069 <sup>NS</sup>	0.48	0.015 <sup>NS</sup>	0.02	0.107*	1.14	0.058 <sup>NS</sup>	0.34

## STANDING HEIGHTS :

## CIRCUMFERENCE MEASUREMENTS :

\*\* Significant at .01, \* Significant at .05, NS Not significant

two handed reach when standing close to the wall, 15 to 30 cm away from wall and also upward one hand reach at 15 cm away from wall. The maximum vertical reaches at different distances revealed high relationship with stature with the percentage relationship and correlation coefficient of 71.40 per cent,  $r=0.845$  (close to the wall) 54.46 per cent,  $r=0.738$  (15 cm away from wall), 43.56 per cent,  $r=0.660$  (30 cm away from wall) and 59.29 per cent,  $r=0.770$  (upward one hand reach) respectively. Arm span, arm length, elbow height, eye height and functional reach-1 and 2 were the other standing height which showed considerable percentage relationship and coefficient of correlation with the maximum vertical reaches.

The relationship between downward reach and normal vertical two hand reach at 15 and 30 cm away from wall and the selected anthropometric measurements was not encouraging.

Relationship of circumference measurements with vertical reaches :

The percentage relationship of all selected circumference measurements with various vertical reaches was found to be low ranging from 0.64 per cent to 2.99 per cent (range of correlation coefficient was 0.08 to 0.173). However they maintained a trend of significant positive relationship.

Further, to predict the dependent variables (reaches) from the independent variables (anthropometric characteristics) stepwise regression analysis was computed.

The measurements of all 526 women on 18 predictor variables (anthropometric variables) and criterion variables (vertical reaches) were used in the stepwise multiple regression analysis to derive efficient predictor variables. The results presented in Table-16, indicate that the addition of number of anthropometric variables significantly contributed to the prediction of various vertical reaches.

Maximum vertical two handed reach close to the wall :

Among the significant predictors, stature (st) entered as the first variable in the regression analysis. It yielded a multiple correlation of 0.844 accounting for 71.22 per cent of variance in maximum vertical two handed reach standing close to the wall. With the introduction of arm span (As) as the succeeding variable, the multiple correlation increased to 0.871, which explained an additional 4.60 per cent of variation ( $R^2=0.7583$ ). The addition of subsequent predictor variables namely eye level (Eyl), functional reach-2 (Fr-2), elbow height (Eh) and arm length (AL), did not increase the multiple correlation obviously and explanation of variation in the criterion variables due to additional predictor variables was negligible. The total predicted variance with the addition of these 5 variables to the stature increased by nearly 7.6 per cent (71.22 to 78.85 per cent). It was statistically significant at or beyond 0.05 level.

TABLE : 16. Stepwise Multiple Regression Analysis of Vertical Reaches and Anthropometric Variables (N=526).

Variables			R	R <sup>2</sup>	SE	F-value	
Max. V. two handed reach	Close to wall	St	0.8442	0.7122	5.04	1300.39**	
		As	0.8713	0.7583	4.61	824.96**	
		Eyh	0.8801	0.7733	4.47	598.07**	
		Fr-2	0.8836	0.7792	4.41	464.21**	
		Eh	0.8879	0.7864	4.34	387.77**	
	A1	0.8893	0.7885	4.32	327.34**		
	15 cm away from wall	Eyh	0.4325	0.1855	14.77	120.64**	
		Fr-2	0.4550	0.2040	14.60	68.29**	
		A1	0.4636	0.2104	14.54	47.66**	
	30 cm away from wall	Eyh	0.6285	0.3950	9.97	342.21**	
		As	0.6548	0.4266	9.70	196.37**	
		Fr-2	0.6615	0.4343	9.63	135.40**	
	Upward and downward reach for right hand 15 cm away from wall	Upward reach	As	0.5218	0.2709	12.20	196.13**
			Fa1	0.5392	0.2880	12.06	107.21**
			Eyh	0.5560	0.3052	11.91	77.88**
A1			0.5609	0.3093	11.88	59.80**	
Downward reach		Eh	0.1356	0.0165	14.74	9.82**	
		Fr-1	0.1747	0.0268	14.66	8.24**	
Reach span	Close to wall	As	0.4042	0.1617	14.57	102.33**	
Nor. V. two handed reach	15 cm away from wall	Eh	0.2806	0.0770	9.20	44.80**	
		Lua	0.3005	0.0868	9.15	25.97**	
		Lh	0.3124	0.0924	9.12	18.82**	
	30 cm away from wall	As	0.3342	0.1100	9.27	65.90**	
		Lfa	0.3833	0.1436	9.09	45.04**	
		Fr-1	0.4224	0.1737	8.93	37.79**	
		Eh	0.4322	0.1806	8.89	29.93**	
		Lua	0.4406	0.1864	8.86	25.06**	

\*\* - Significant at 0.01 level

\* - Significant at 0.05 level

Maximum vertical two handed reach 15 cm away from wall :

To predict two handed reach standing at 15 cm away from wall, eye height (Eyh) was the first significant predictor variable that explained 18.55 per cent variation in the reach ( $R=0.4325$ ). This was followed by functional reach-2 and arm length. These two had increased the multiple correlation value to 0.4550 with additional 1.89 per cent ( $R^2=0.2040$ ) and 0.4636 with 0.01 per cent ( $R^2=0.2104$ ) of variation respectively. However, the total variance explained by these variables was low but it was significant.

Maximum vertical two handed reach 30 cm away from wall :

To estimate two handed reach standing 30 cm away from the wall, the most significant predictor variable was eye height which explained 39.50 per cent variance in the reach ( $R=0.6285$ ). Next to this, arm span showed the increment in multiple correlation (0.6548) with 42.66 per cent variation (the additional variance was found to be 3.16 per cent). The accountability of third predictor variable i.e., functional reach-2, was not obvious. Statistically these were significant.

Upward reach :

To predict upward reach standing 15 cm away from wall, arm span was the first predictor accounted for 27.09 per cent of variation in reach ( $R=0.5218$ ). In second place forearm length (Fal) revealed a multiple correlation of 0.5392 with 1.72 per cent additional variation ( $R^2=0.2880$ ). The role

of subsequent predictor variables was not sizeable. For lower reach prediction elbow height and functional reach-1 entered the stepwise regression analysis as first and second predictor variables respectively. But, their multiple correlation and  $R^2$  values indicated poor linear relationship.

Reach span :

To estimate the reach span when standing close to the wall, arm span was the only predictor variable which entered the stepwise regression analysis. Its multiple correlation and percentage of variation in the criterion variable was 0.4042 and 16.17 per cent respectively and found to be significant.

Normal two handed reach :

For prediction of normal two handed reach standing at 15 cm away from wall, the identified significant predictor variables were elbow height, upper arm length and leg height. However, these revealed low linear relationship. The total predicted variance was found to be 07.70 to 09.24 per cent with multiple correlation of 0.2806 to 0.3124. Estimation of two handed reach standing 30 cm away from wall involved five predictor variables. Among them, arm span identified as the first significant variable. Its multiple correlation was found to be 0.3342 with 11.00 per cent variance. The addition of another 4 predictors namely forearm length, functional reach-1, elbow height and upper arm length, increased the multiple correlation significantly to 0.4406 and percentage

variation to 18.64 per cent (additional 7.64 per cent of variation).

Based on stepwise regression analysis, it could be concluded that maximum two handed reach standing close to the wall had high linear relationship with stature and arm span. However, moving away from wall i.e., 15 and 30 cm, the linear relationship between these two predictor variables and criterion variable (maximum two handed reach) is not maintained. But, other predictors such as eye height, arm length, functional reach-2, arm span explained their relationship in causing the variations. But it was not impressive in terms of their linearity with the criterion variables. From this it can be inferred that large variation in reaches which was not accounted for, could be due to other factors which are not considered under the study (regression coefficients and constant values Table-66 in Appendix-5).

#### SHELF HEIGHT REACHES :

Top shelf height and depth reach vary when there is no obstacle and in the presence of obstacle between the worker and the shelf (Table-17). The mean top shelf height reach without obstacle was 178.11 cm while with obstacle the reach was reduced to 170.90 cm. The mean lower shelf height reach was found to be 72.72 cm. However, not much variation was noticed between downward one hand reach and lower shelf height reach (Fig. 13).

TABLE : 17. Mean Shelf Height and Depth  
Reaches (N=526).

Variables	Reaches		
	Min. cm	Max. cm	Mean cm
Top shelf height reach without obstacle	150.00	207.00	178.111
Top shelf height reach with obstacle	103.00	204.00	170.900
Top shelf depth reach without obstacle	13.00	18.50	15.314
Top shelf depth reach with obstacle	12.00	18.00	14.718
Lower shelf height reach	61.00	85.00	72.729
Lower shelf depth reach	11.00	17.00	14.179

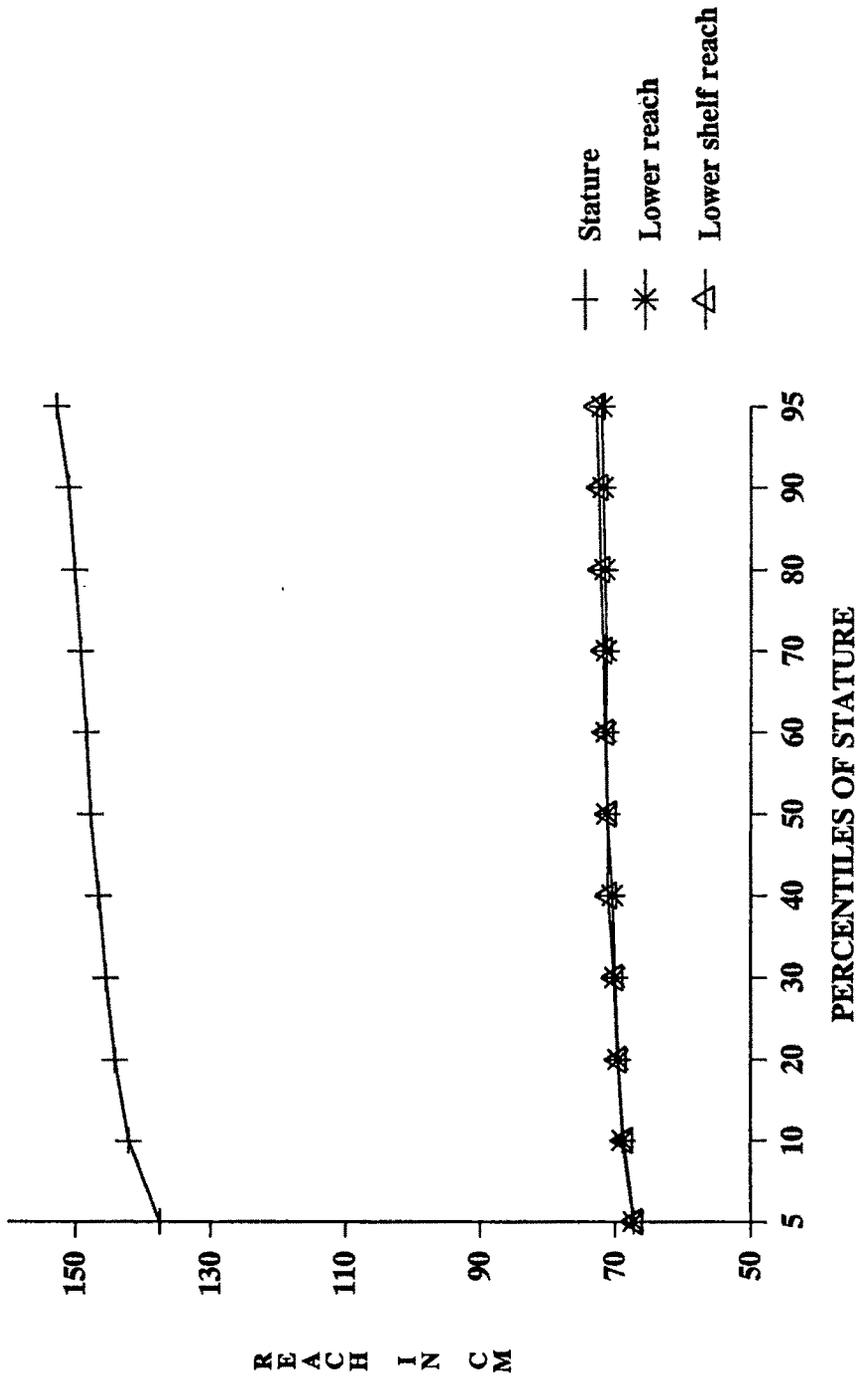


Fig. 13. A COMPARISON BETWEEN DOWNWARD ONEHAND REACH AND LOWER SHELF HEIGHT REACH WITH REFERENCE TO STATURE

Regarding the shelf depth reach, mean depth reach was 14 cm and 15 cm with and without obstacle respectively. It was not found to be affected much with presence of obstacle between the worker and the shelf.

Top shelf height reach and depth reach with and without obstacle and lower shelf height and depth reach is presented (Fig. 14) for various percentile groups with reference to stature (Table-67 in Appendix-6).

Relationship of standing heights with shelf height reaches :

All standing heights revealed a positive significant relationship with different shelf height and depth reaches (Table-18). Stature 73.79 per cent ( $r=0.859$ ), eye height 71.32 per cent ( $r=0.844$ ), arm span 66.91 per cent ( $r=0.818$ ) and elbow height 65.12 per cent ( $r=0.807$ ) showed a high percentage relationship with top shelf height reach without obstacle. Also the percentage relationship of above mentioned anthropometric measurements with top shelf height reach with obstacle was considerable with percentage ranging between 51.41 to 58.06 (correlation coefficient ranged from 0.717 to 0.762).

Not much variation was noticed in the percentage relationship of lower shelf height reach with the elbow height (53.43 per cent,  $r=0.731$ ) eye height (52.27 per cent,  $r=0.723$ ) and stature (50.27 per cent,  $r=0.709$ ).

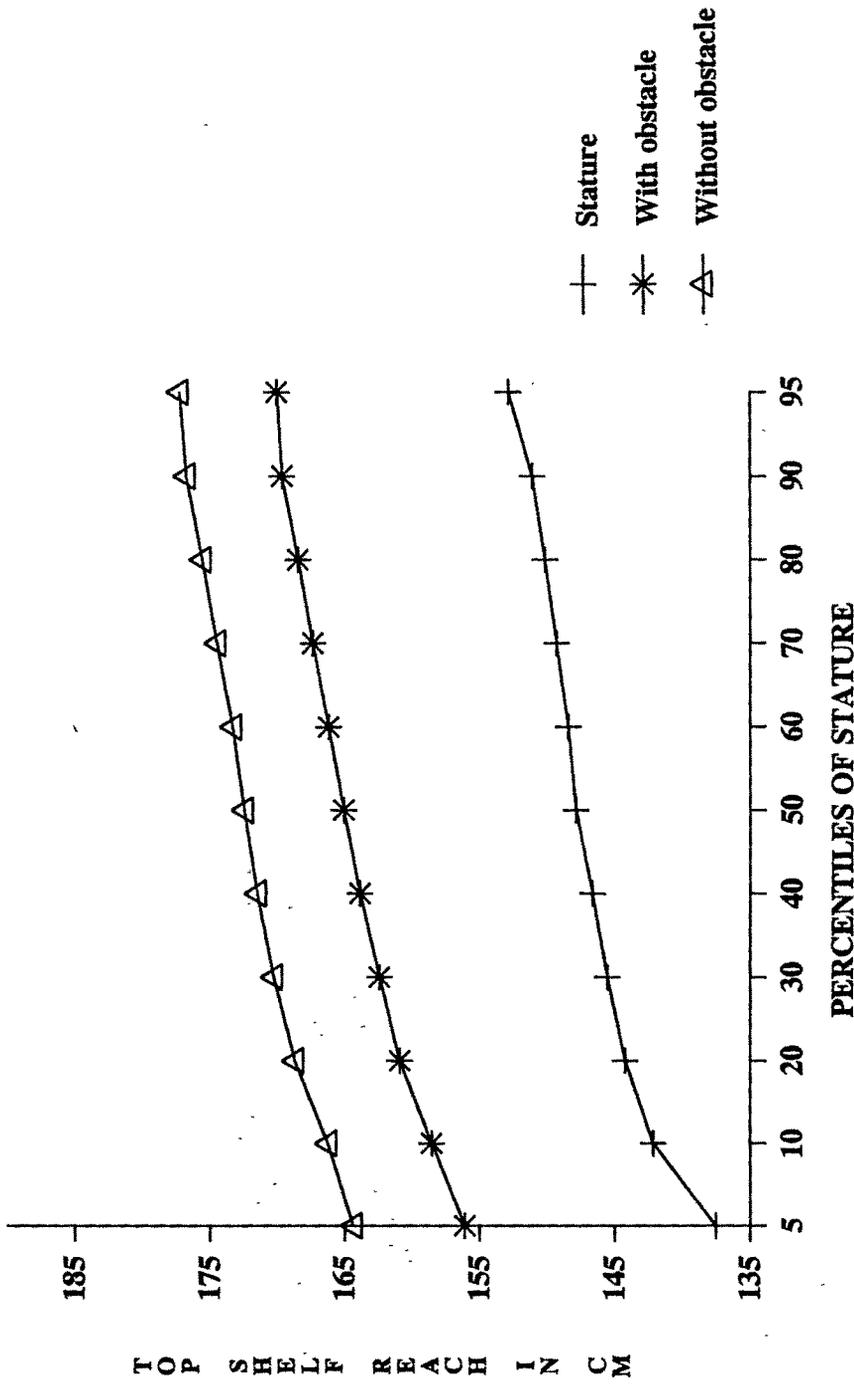


Fig. 14. TOP SHELF HEIGHT REACH WITH AND WITHOUT OBSTACLE WITH REFERENCE TO STATURE

TABLE : 18. Correlation Coefficient and Percentage Relationship of Anthropometric Variables and Shelf Reaches.

Anthropometric variables	Top shelf height		Top shelf height reach with obstacle		Top shelf depth		Top shelf depth reach with obstacle		Lower shelf height		Lower shelf height reach without obstacle		Lower shelf depth		Lower shelf depth reach without obstacle																																																																																																																																			
	r	r <sup>2</sup>	r	r <sup>2</sup>	r	r <sup>2</sup>	r	r <sup>2</sup>	r	r <sup>2</sup>	r	r <sup>2</sup>	r	r <sup>2</sup>	r	r <sup>2</sup>																																																																																																																																		
<b>STANDING HEIGHTS :</b>																																																																																																																																																		
Stature	0.859**	73.79	0.762**	58.06	0.393**	15.44	0.460**	21.16	0.709**	50.27	0.340**	11.56	0.818**	66.91	0.714**	50.98	0.491**	24.11	0.540**	29.16	0.491**	24.11	0.391**	15.29	0.690**	47.61	0.630**	39.69	0.405**	16.40	0.458**	20.98	0.412**	16.97	0.370**	13.69	0.807**	65.12	0.717**	51.41	0.312**	9.73	0.374**	13.99	0.731**	53.43	0.305**	9.30	0.600**	36.00	0.517**	26.73	0.298**	8.88	0.376**	14.14	0.373**	13.91	0.292**	8.52	0.401**	16.08	0.333**	11.09	0.222**	4.93	0.215**	4.67	0.195**	3.80	0.213**	4.54	0.526**	27.67	0.445**	19.80	0.465**	21.62	0.513**	26.31	0.430**	18.49	0.408**	16.65	0.549**	30.14	0.472**	22.28	0.211**	4.45	0.258**	6.66	0.398**	15.84	0.229**	5.24	0.591**	34.93	0.547**	29.92	0.230**	5.29	0.298**	8.88	0.460**	21.62	0.723**	52.27	0.130**	1.69	0.844**	71.32	0.747**	55.80	0.386**	14.90	0.460**	21.62	0.449**	20.16	0.310**	9.61	0.633**	40.06	0.595**	35.40	0.391**	15.29	0.468**	21.90	0.449**	20.16	0.310**	9.61	0.637**	40.57	0.595**	35.40	0.391**	15.29	0.469**	21.99	0.455**	20.70	0.308**	9.48
<b>CIRCUMFERENCE MEASUREMENTS :</b>																																																																																																																																																		
Bust	-0.006 <sup>NS</sup>	0.00	-0.037 <sup>NS</sup>	0.13	0.052 <sup>NS</sup>	0.27	-0.094*	0.88	0.015 <sup>NS</sup>	1.32	-0.053 <sup>NS</sup>	0.28	-0.018 <sup>NS</sup>	0.03	-0.053 <sup>NS</sup>	0.28	0.017 <sup>NS</sup>	0.02	-0.141**	1.99	0.058 <sup>NS</sup>	0.34	-0.077 <sup>NS</sup>	0.59	0.087*	0.76	0.030 <sup>NS</sup>	0.09	0.063 <sup>NS</sup>	0.40	-0.217**	4.71	0.019 <sup>NS</sup>	0.03	-0.156**	2.43	-0.062 <sup>NS</sup>	0.38	-0.099 <sup>NS</sup>	0.35	0.055 <sup>NS</sup>	0.37	0.031 <sup>NS</sup>	0.10	-0.003 <sup>NS</sup>	0.00	0.006 <sup>NS</sup>	0.00	-0.045 <sup>NS</sup>	0.25	-0.106*	1.12	0.073 <sup>NS</sup>	0.53	-0.039 <sup>NS</sup>	0.15	0.046 <sup>NS</sup>	0.21	-0.007 <sup>NS</sup>	0.00	0.062 <sup>NS</sup>	0.38	-0.123**	1.51	0.030 <sup>NS</sup>	0.09	-0.038 <sup>NS</sup>	0.14																																																																														

\*\* Significant at .01, \* Significant at .05, NS Not significant

Among the standing heights arm span revealed the highest percentage relationship with shelf depth reach with and without obstacle.

Relationship of circumference measurements with shelf height reaches :

In general the percentage relationship of circumference measurements with various shelf height and depth reaches was low ranging from 0.76 to 4.71 per cent.

Thus, it can be concluded that, stature has a high percentage relationship with top shelf height reach (with and without obstacle) while, lower shelf height with elbow height.

Further, to predict the dependent variable from independent variables stepwise multiple regression analysis was computed.

Eighteen predictor variables (anthropometric measurements) and criterion variables (shelf reaches) were used in the stepwise multiple regression analysis to identify efficient predictor variables (Table-19).

Top shelf height reach without obstacle :

According to the results of stepwise multiple regression, stature was found to be the dominant significant predictor variable as it entered as the first. It revealed a multiple correlation of 0.650 explaining 42.18 per cent of variation in the top shelf height reach without obstacle. The addition of subsequent four variables viz., arm span, elbow

TABLE : 19. Stepwise Multiple Regression Analysis of Shelf Reaches and Anthropometric Variables (N=526).

Variables		R	R <sup>2</sup>	SE	F-value
Top shelf height reach without obstacle	St	0.6503	0.4218	8.18	384.02**
	As	0.6620	0.4362	8.07	204.10**
	Eh	0.6707	0.4467	8.00	142.28**
	Buc	0.6752	0.4518	7.96	109.18**
	Abc	0.6787	0.4554	7.93	88.83**
Top shelf depth reach without obstacle*		0.1239	-0.0216	9.26	0.42 <sup>NS</sup>
Top shelf height reach with obstacle	St	0.5261	0.2754	12.00	200.63**
	Buc	0.5392	0.2880	11.89	107.23**
	Eyh	0.5477	0.2960	11.83	74.58**
Top shelf depth reach with obstacle*		0.1850	-0.0020	16.02	0.94 <sup>NS</sup>
Lower shelf height reach	Eh	0.3466	0.1185	8.37	71.58**
	Fr-2	0.3606	0.1267	8.33	39.11**
	As	0.3755	0.1361	8.29	28.58**
	Fac	0.3888	0.1446	8.25	23.20**
Lower shelf depth reach	As	0.1319	0.0155	8.10	9.29**
	H1	0.1679	0.0245	8.06	7.59**
	St	0.1907	0.0308	8.04	6.57**

\* No variables entered stepwise regression analysis

\*\* - Significant at 0.01 level

height, bust circumference and abdominal circumference increased the multiple correlation from 0.650 to 0.678. The addition of these variables to stature caused the additional 03.36 per cent variation in the criterion variable (42.18 to 45.54). Statistically this was significant at or beyond 0.05 level.

Top shelf height reach with obstacle :

To predict top shelf height reach with obstacle, stature was found to be the first significant variable. It yielded a multiple correlation of 0.526, accounting for 27.54 per cent of criterion variability. The additional predicted variance has increased by 2.06 per cent with the addition of two more variables i.e., bust circumference ( $R=0.539$ ,  $R^2=0.2880$ ), eye height ( $R=0.547$ ,  $R^2=29.60$ ) and they were found to be statistically significant at or beyond 0.05 level.

Lower shelf height reach :

To estimate lower shelf height reach the significant variable was the elbow height. Its  $R$  was found to be 0.346 with 11.85 per cent of variation in the reach. Although the subsequent variables namely functional reach-2, arm span and forearm circumference raised the multiple correlation (0.346 to 0.388) and percentage variation (11.85 to 14.46) it was found to be marginal (2.61 per cent) and significant.

Top shelf depth reach :

No predictor variables entered stepwise regression analysis to estimate the variation in the top shelf depth

reach with and without elbow level obstacle. Therefore, multiple regression analysis was computed.  $R^2$  was not found to be encouraging and statistically not significant.

Lower shelf depth reach :

To predict lower shelf depth reach, arm span, hand length and stature entered the stepwise analysis in order. However, their multiple correlation were less than 0.20 and accountability for percentage variation was negligible (less than 1 per cent). However, they were statistically significant at or beyond 0.05 level.

Based on the above findings it may be concluded that, stature is the most appropriate predictor variable to predict top shelf height reach with and without obstacle. Lower shelf height reach is related with the elbow height while depth is associated with arm span. Based on their accountability for percentage variation in shelf reaches it may be concluded that there could be other predictor variables associated with the criterion variables, which are not considered under the study (regression co-efficients and constant values Table-68 in Appendix-7).

HORIZONTAL REACHES :

Horizontal reaches on the surface while standing were studied at different elbow heights for maximum and normal reaches (Table-20). At elbow height, the mean maximum horizontal two handed reach was found to be 44.17 cm. The mean maximum reach at the work surface of 10 cm and 5 cm below

TABLE : 20. Mean Horizontal Reaches (N=526).

Horizontal reaches	Level of elbow heights	Minimum	Maximum (cm)	Mean
Max. two handed	Elbow height	27.00	61.00	44.177
	5cm below elbow height	25.00	57.00	41.414
	10cm below elbow height	24.00	55.50	39.364
Max. one handed (right hand)	Elbow height	35.00	65.00	47.727
	5cm below elbow height	26.50	61.00	44.835
	10cm below elbow height	25.00	60.00	42.815
Nor. two handed	Elbow height	10.50	41.00	18.575
	5cm below elbow height	10.00	36.00	17.560
	10cm below elbow height	8.00	31.00	16.667

the elbow height was 39.36 and 41.41 cm respectively. These findings reflect that as the surface height is lower there is more reduction in mean maximum horizontal reaches. The same trend was observed even in the case of one hand reach. It was also noticed that maximum reach for one hand (right) was more when compared to two handed maximum reach. The right hand maximum horizontal reach at different elbow heights is a mirror image for left hand also.

Regarding normal horizontal two handed reach, mean reach at elbow height was 18.57 cm followed by 17.56 cm at 5 cm below elbow height and 16.66 cm at 10 cm below elbow height.

Various horizontal reaches on work surface at different elbow heights were further analysed for different percentile groups with reference to elbow height. It is presented in Fig. 15 (Table-69 in Appendix-8).

Further the figures 16, 17, 18 revealed the angle of bend between upper arm and forearm for 5th, 50th and 95th percentile for normal two handed reach on the work surface at different elbow height. It was found that the angle of bend was maximum (Fig. 19) when work surface was 10 cm below elbow height for 5th percentile i.e.  $128.5^{\circ}$  ( $90^{\circ} + 38.5^{\circ}$ ), 50th percentile  $119^{\circ}$  ( $90^{\circ} + 29^{\circ}$ ), 95th percentile  $113.5^{\circ}$  ( $90^{\circ} + 23.5^{\circ}$ ). However 5th percentile group revealed higher elbow extension when compared to other two groups also the percentage reduction (Fig. 20) of normal reach was high for 5th percentile and was not linear in relation.

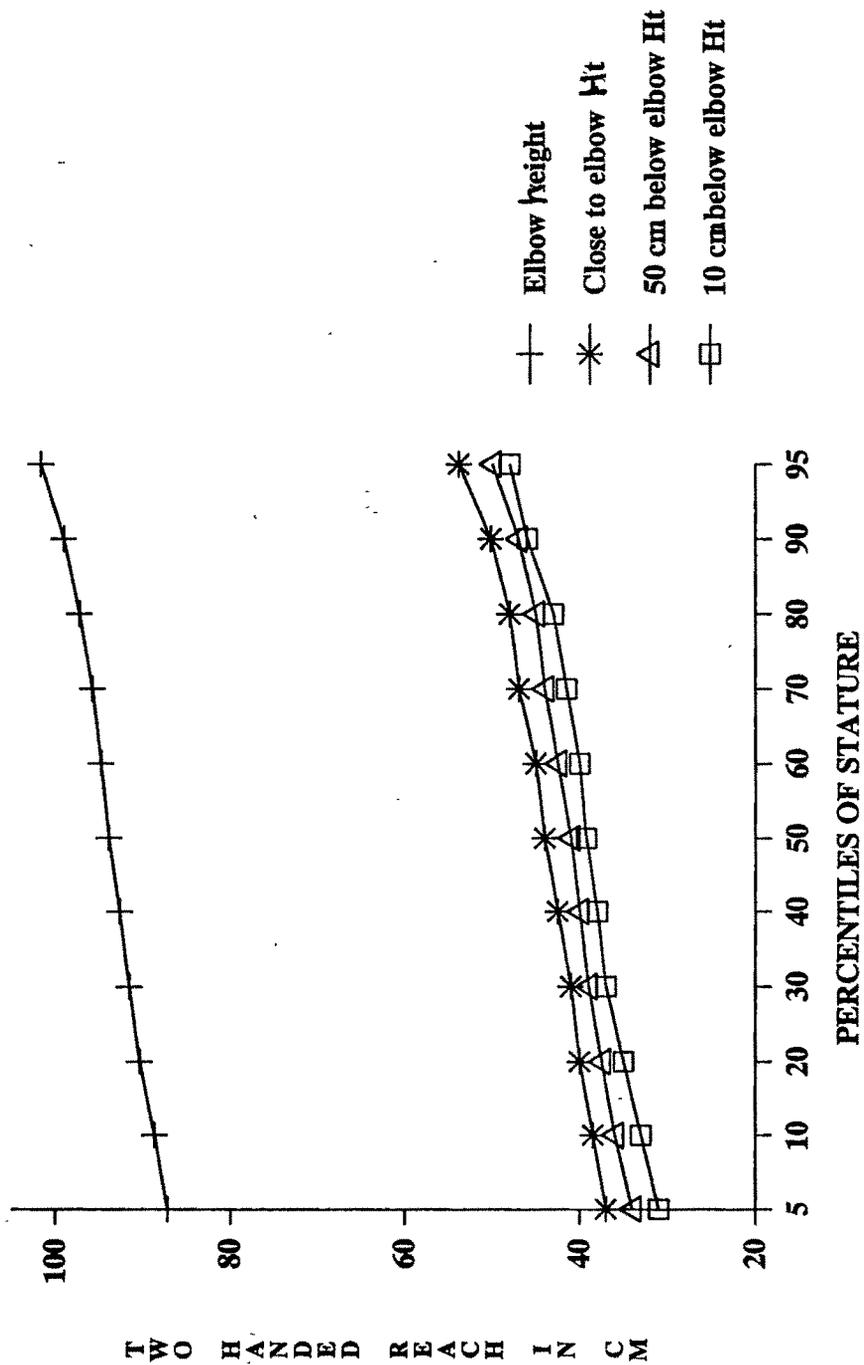


Fig. 15. PERCENTILE DISTRIBUTION OF HORIZONTAL TWO HANDED REACHES AT DIFFERENT ELBOW HEIGHTS

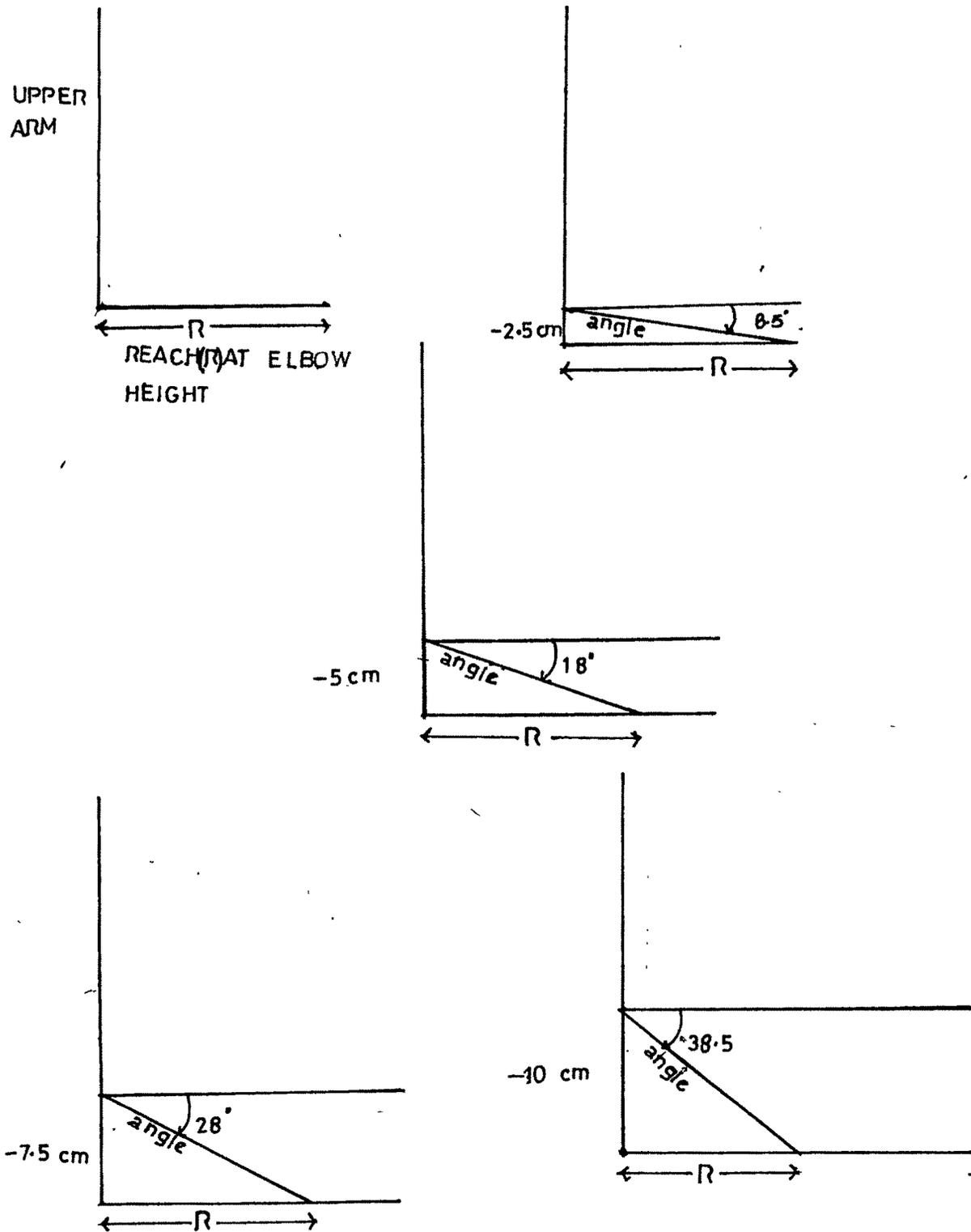


FIG. 16. NORMAL HORIZONTAL REACH AND ANGLES OF ELBOW BEND FOR 5TH PERCENTILE WOMEN AT VARIOUS WORK SURFACE LEVELS.

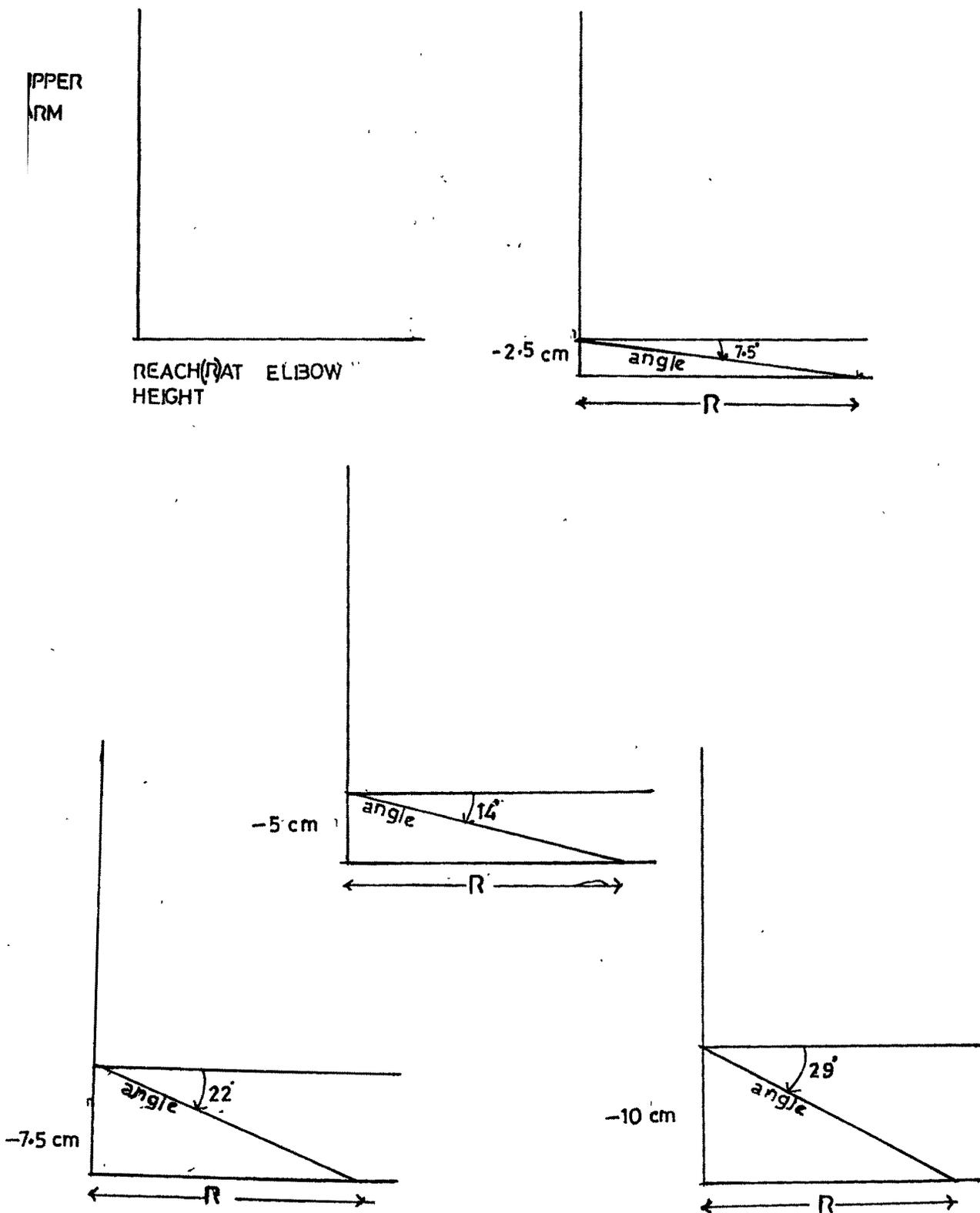


FIG.17. NORMAL HORIZONTAL REACH AND ANGLES OF ELBOW BEND FOR 50TH PERCENTILE WOMEN AT VARIOUS WORK SURFACE LEVELS.

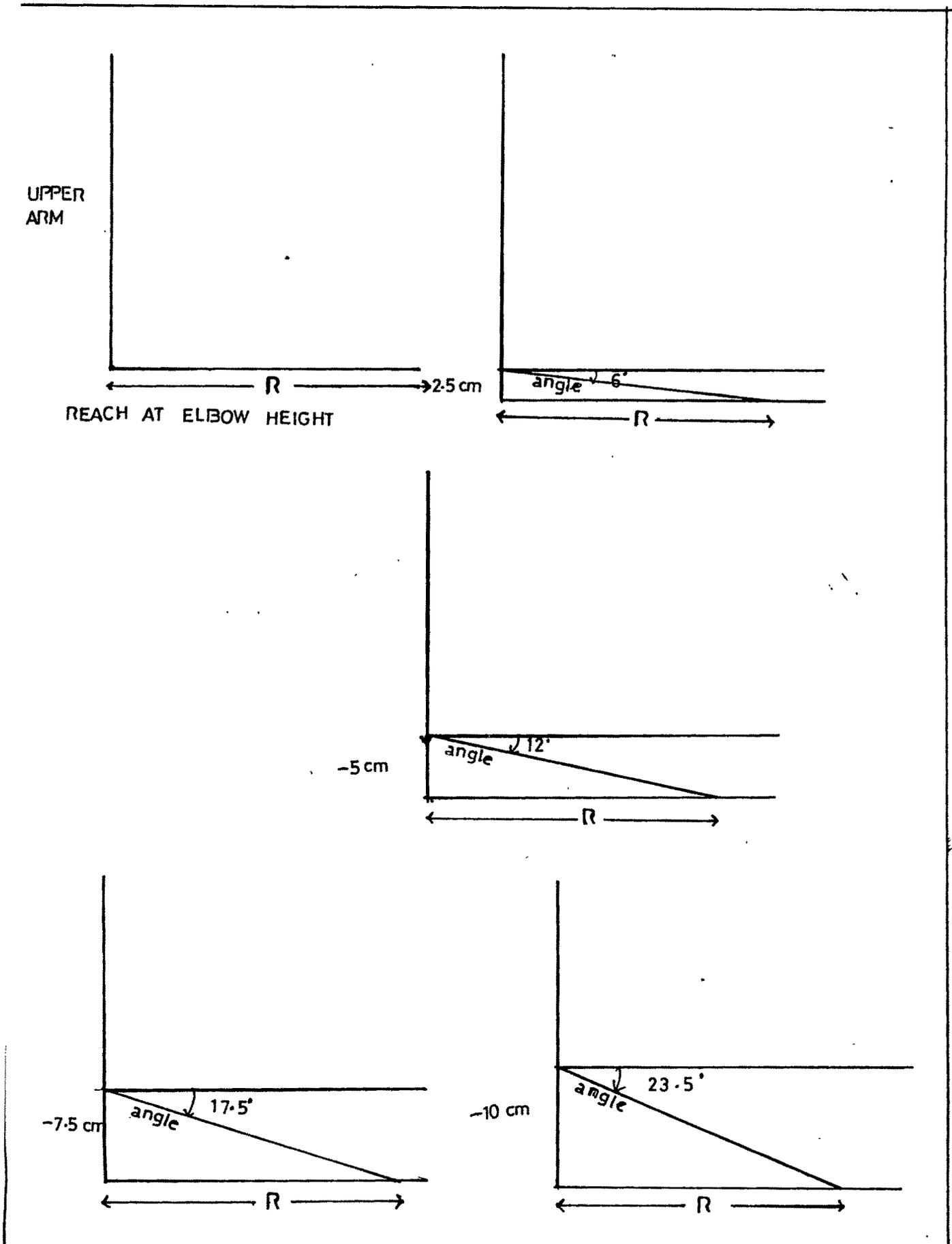


FIG.18. NORMAL HORIZONTAL REACH AND ANGLES OF ELBOW BEND FOR 95TH PERCENTILE WOMEN AT VARIOUS WORK SURFACE LEVELS.

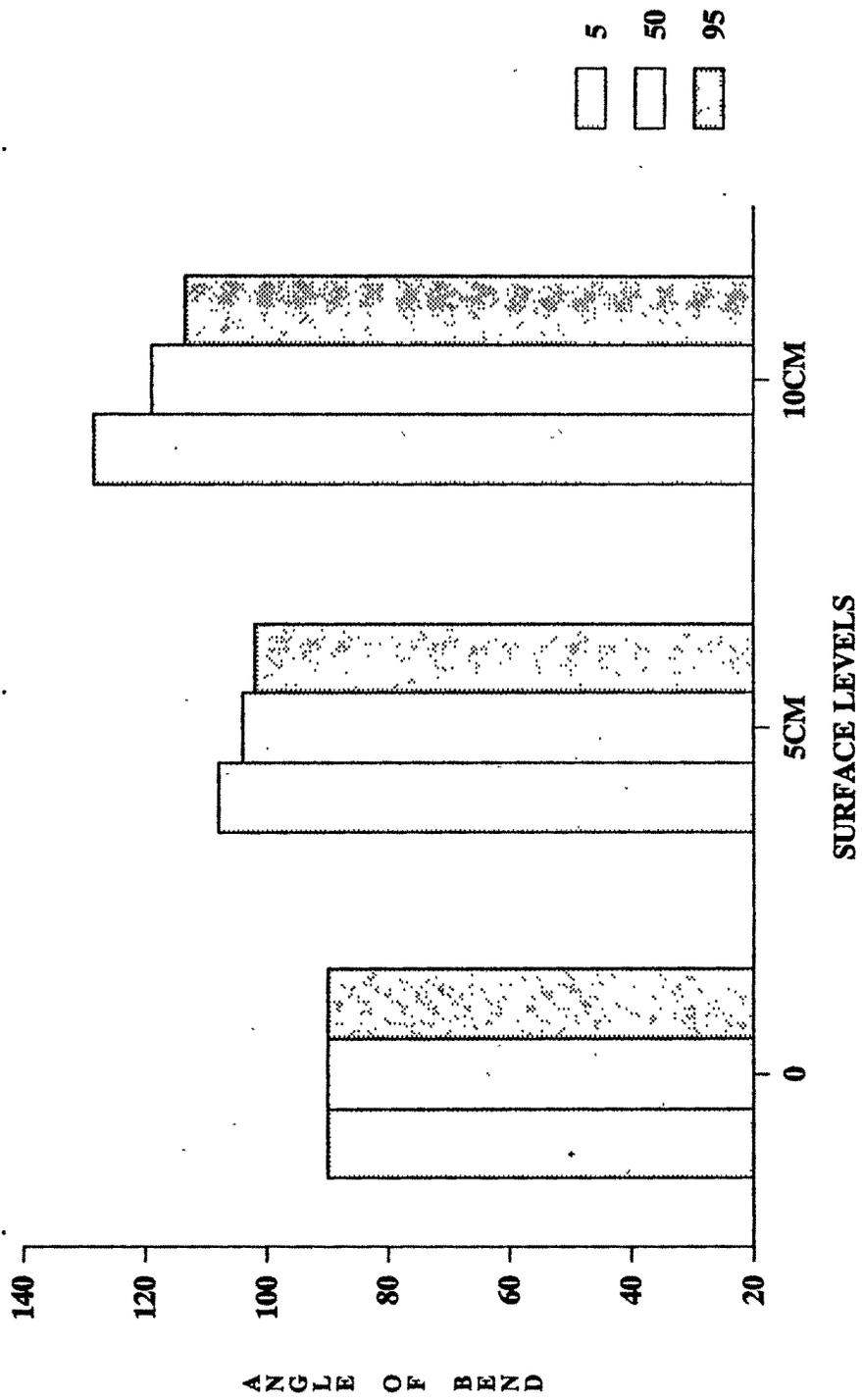


Fig. 19. ANGLE BETWEEN UPPER AND FOREARM FOR NORMAL HORIZONTAL REACH ON THE SURFACE AT VARIOUS LEVELS

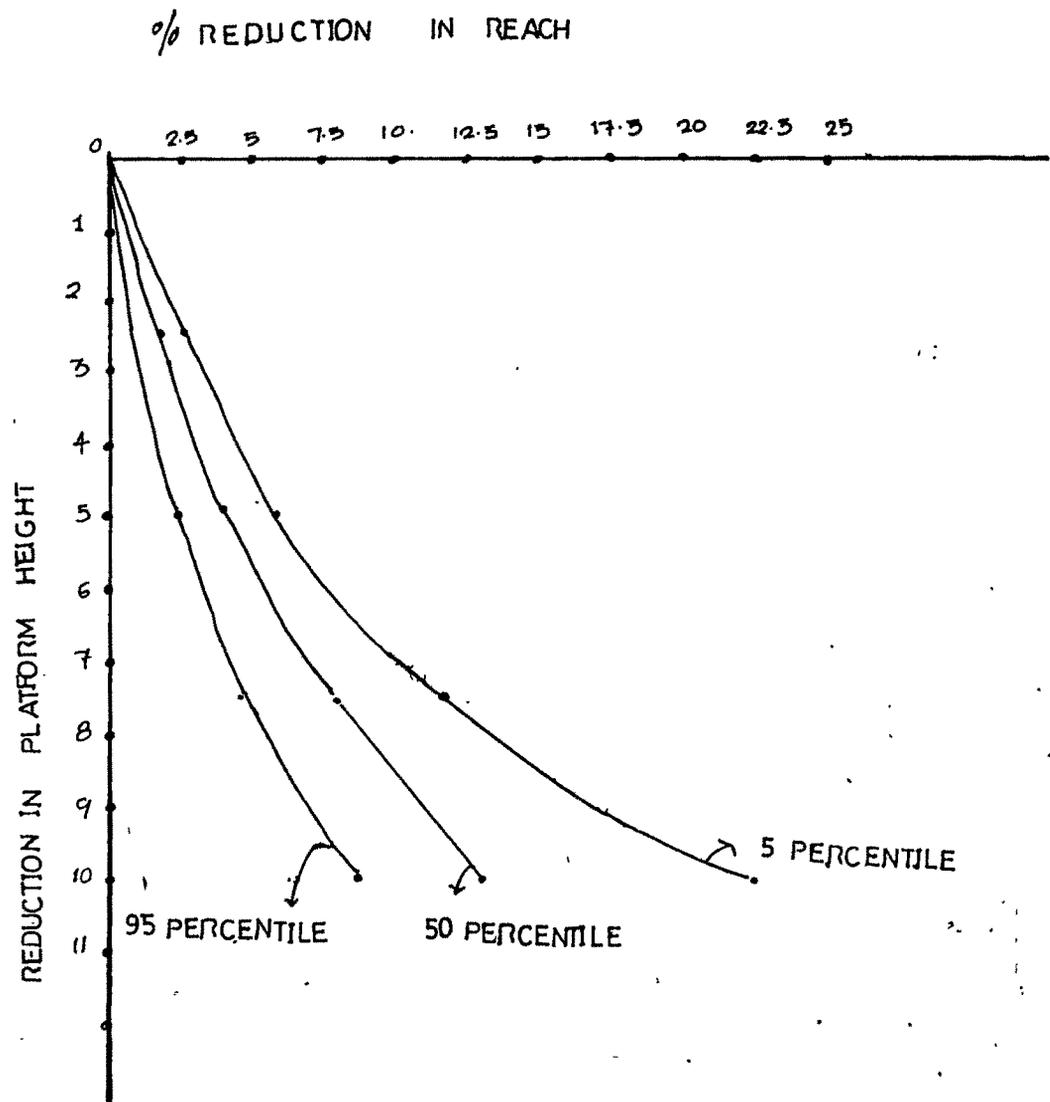


FIG.20. PERCENTAGE REDUCTION IN REACH ACCORDING TO THE PLATFORM HEIGHT FOR VARIOUS PERCENTILE GROUPS.

So, it can be concluded that, the work surface at 10 cm below elbow is not found to be appropriate as the angle of bend between upper and forearm is higher and as a result, the arm moves away from the state of equilibrium. As the percentage of reduction in reach on work surface at 10 cm below elbow height is higher and on the criteria of angle of elbow extension between upperarm and forearm, the work surface height could be varied from elbow height to 2.5 or 5 cm below elbow height.

Relationship of standing height with horizontal reaches :

Correlation coefficients were computed to study the relationship between various horizontal reaches and the selected anthropometric variables (Table-21). All the standing heights were positively related at or beyond 0.05 level with maximum two handed and maximum one hand reach. Among the anthropometric variables elbow height had highest percentage relationship of 22.75 per cent ( $r=0.477$ ) with maximum two handed at elbow height, 21.07 per cent ( $r=0.459$ ) at 5 cm below elbow and 20.52 per cent ( $r=0.453$ ) at 10 cm below elbow height. Also percentage relationship of maximum one hand reach with elbow height was high ranging between 23.61 to 25.00 per cent (correlation coefficient ranging from 0.486 to 0.500) at three levels of elbow height.

The percentage relationship of standing heights with normal two handed reach was not striking. However among the selected anthropometric measurements normal two handed reach

TABLE : 21. Correlation Coefficient and Percentage Relationship of Anthropometric Variables and Horizontal Reaches (N=526).

Anthropometric variables	Max H. two handed reach			Nor. H. two handed reach			Max H. reach for one hand (right hand)									
	close to elbow	5 cm below	10 cm below	close to elbow	5 cm below	10 cm below	close to elbow	5 cm below	10 cm below	close to elbow	5 cm below	10 cm below	r	r <sup>2</sup>		
Stature	0.435**	0.416**	0.410**	0.272**	0.271**	0.251**	7.40	7.34	7.34	6.30	0.460**	21.16	0.451**	20.88	0.445**	19.80
Arm span	0.411**	0.413**	0.393**	0.301**	0.305**	0.268**	9.06	9.30	9.30	7.18	0.447**	13.98	0.446**	19.89	0.422**	17.81
Arm length	0.404**	0.381**	0.401**	0.280**	0.303**	0.283**	7.84	9.18	9.18	8.00	0.435**	18.92	0.435**	18.58	0.401**	16.08
Elbow height	0.477**	0.489**	0.453**	0.256**	0.309**	0.309**	6.55	9.55	9.55	9.54	0.500**	25.00	0.507**	25.70	0.466**	23.61
Upperarm length	0.232**	0.273**	0.228**	0.147**	0.220**	0.217**	2.15	4.84	4.84	4.71	0.261**	6.81	0.262**	6.86	0.205**	4.24
Forearm length	0.304**	0.250**	0.294**	0.193**	0.298**	0.338**	3.72	8.88	8.88	11.42	0.301**	9.06	0.302**	9.12	0.300**	9.00
Hand length	0.179**	0.197**	0.171**	0.170**	0.178**	0.151**	2.89	3.17	3.17	2.28	0.201**	4.04	0.220**	4.84	0.198**	3.96
Leg height	0.397**	0.372**	0.381**	0.230**	0.282**	0.290**	5.29	7.95	7.95	8.41	0.417**	17.39	0.408**	16.48	0.399**	14.36
Lower leg height	0.290**	0.308**	0.355**	0.161**	0.172**	0.167**	2.59	2.96	2.96	2.79	0.284**	8.07	0.296**	8.76	0.268**	7.18
Eye height	0.401**	0.374**	0.372**	0.278**	0.278**	0.249**	7.73	7.73	7.73	6.20	0.422**	17.81	0.431**	18.58	0.404**	16.32
Functional reach-1	0.162**	0.178**	0.191**	0.126**	0.092**	0.025**	1.59	0.85	0.85	0.06	0.203**	4.12	0.224**	5.02	0.182**	3.31
Functional reach-2	0.159**	0.175**	0.190**	0.123**	0.085**	0.020**	1.51	0.72	0.72	0.04	0.200**	4.00	0.221**	4.88	0.180**	3.24
Bust	-0.248**	-0.211**	-0.228**	-0.010**	-0.049**	-0.025**	0.01	0.24	0.24	0.05	-0.254**	6.45	-0.256**	6.55	-0.199**	3.96
Upper arm	-0.202**	-0.150**	-0.175**	-0.004**	-0.022**	-0.061**	0.00	0.05	0.05	0.37	-0.190**	3.61	-0.200**	4.00	-0.140**	1.96
Forearm	-0.165**	-0.089**	-0.117**	-0.034**	-0.080**	-0.084**	0.12	0.64	0.64	0.71	-0.153**	2.34	-0.143**	2.04	-0.082**	0.67
Waist	-0.277**	-0.245**	-0.250**	-0.063**	-0.095**	-0.057**	0.40	0.90	0.90	0.32	-0.282**	7.95	-0.280**	7.84	-0.224**	5.02
Abdomen	-0.300**	-0.266**	-0.275**	-0.054**	-0.091**	-0.065**	0.29	0.83	0.83	0.42	-0.294**	8.64	-0.292**	8.53	-0.230**	5.29
Hip	-0.262**	-0.211**	-0.228**	-0.018**	-0.018**	-0.003**	0.01	0.03	0.03	0.00	-0.242**	5.86	-0.233**	5.43	-0.181**	3.28

\*\* Significant at .01, \* Significant at .05, NS Not significant

CIRCUMFERENCE MEASUREMENTS :

had noticeable relationship with arm span at various elbow levels work surface.

Relationship of circumference measurements with horizontal reaches :

All horizontal reaches except normal two handed reach were negatively related at 0.05 level with all circumferential measurements. However their percentage relationship and correlation coefficient values were negligible.

Thus, it could be concluded that all standing heights has a positive significant relationship with horizontal maximum two handed and one hand reaches at different work surface levels. However, elbow height and arm span were the dominant independent variables which revealed a noticeable relationship with the dependent variables. The relationship of circumferential measurements and horizontal maximum two handed reaches was negative.

Further, to predict dependent variables from independent variables stepwise multiple regression analysis was computed.

Among 18 predictor variables, elbow height turned out to be the first significant variable in the stepwise multiple regression analysis for the estimation of all maximum horizontal reaches (Table-22).

TABLE : 22. Stepwise Multiple Regression Analysis of Horizontal Reaches and Anthropometric Variables (N=526).

Variables			R	R <sup>2</sup>	SE	F-value
Max. H. two handed reach	Close to elbow height	Eh	0.3742	0.1383	6.01	85.32**
		Abc	0.4458	0.1957	5.81	64.88**
		A1	0.4656	0.2123	5.75	48.17**
		Fr-2	0.4845	0.2288	5.68	39.96**
		As	0.5001	0.2429	5.63	34.69**
	5 cm below elbow height	Fac	0.5097	0.2512	5.60	30.36**
		Eh	0.3435	0.1163	5.70	70.10**
		Abc	0.4183	0.1718	5.52	55.47**
		As	0.4431	0.1917	5.45	42.50**
		Fr-2	0.4718	0.2166	5.37	37.30**
	10 cm below elbow height	Eyh	0.4799	0.2229	5.34	31.11**
		Eh	0.4526	0.2033	4.56	134.99**
		Abc	0.5306	0.2788	4.34	102.50**
		A1	0.5607	0.3105	4.24	79.80**
		Eeb	0.5734	0.3237	4.20	63.83**
		Fr-2	0.5795	0.3295	4.19	52.60**
		As	0.5929	0.3440	4.14	46.89**
		Lh	0.5999	3.3512	4.12	41.61**
		Eyh	0.6062	0.3577	4.10	37.55**
		A1	0.6109	0.3623	4.08	34.14**
Nor. H. two handed reach	Close to elbow height	Fa1	0.6166	0.3682	4.06	31.59**
		Ua1	0.6212	0.3728	4.05	29.36**
	Eyh	0.1569	0.0227	10.25	13.22**	
	5 cm below elbow height	Eyh	0.1503	0.0207	12.00	12.11**
		10 cm below elbow height*	0.1290	-0.0202	13.18	0.45 <sup>NS</sup>
Max. H. reach for one hand (Right hand)	Close to elbow height	Eh	0.4999	0.2484	4.19	174.58**
		Abc	0.5809	0.3349	3.94	133.22**
		As	0.6140	0.3734	3.83	105.31**
		Fr-2	0.6443	0.4107	3.71	92.47**
		A1	0.6517	0.4192	3.68	76.78**
	5 cm below elbow height	Eyh	0.6569	0.4250	3.66	65.68**
		H1	0.6618	0.4304	3.65	57.68**
		Fa1	0.6659	0.4349	3.63	51.50**
		Fac	0.6694	0.4385	3.62	46.85**
		Eh	0.1373	0.0169	13.78	10.07**
	10 cm below elbow height*	Abc	0.1698	0.0251	13.72	7.76**
		0.1498	-0.0142	20.82	0.61 <sup>NS</sup>	

NOTE : \* New variables entered stepwise regression analysis  
 \*\* - Significant at 0.01 level

Maximum two handed reach on the surface at elbow height :

It revealed 0.374 multiple correlation with 13.83 per cent of variation in the prediction of maximum two handed reach on the surface close to the elbow height of the user. The second predictor namely abdominal circumference increased the multiple correlation to 0.445 with the additional variation of 5.74 per cent ( $R^2=0.1957$ ). The contribution of other variables namely arm length, functional reach-2, arm span and forearm circumference caused less than 2 per cent of variation. However, addition of these five variables to the elbow height, raised the multiple correlation from 0.374 to 0.509 with the total percentage variation of 11.29 per cent (from 13.83 to 25.12 per cent). They were statistically significant at or beyond 0.05 level. When the work surface height was reduced to 5 and 10 cm below the elbow height, the first two predictor variables viz., elbow height and abdominal circumference maintained their first and second position respectively.

Maximum two handed reach on the surface 5 cm below elbow height :

For the estimation of maximum horizontal two handed reach on the surface when it was 5 cm below elbow height, elbow height revealed a multiple correlation of 0.343 with 11.63 per cent of variation. However, addition of subsequent variables i.e., abdominal circumference and arm span increased sizeable multiple correlation namely 0.418 (increase of 0.075) with 5.55 per cent of variance and 0.443 (increase of 0.025)

with 1.99 per cent respectively. Although other two variables (functional reach-2 and eye height) increased multiple correlation and percentage of variation significantly, it was not impressive. Total rise in multiple correlation due to addition of 4 variables to elbow height was upto 0.479 with 22.29 per cent of variance.

Maximum two handed reach on the surface 10 cm below elbow height :

The involvement of elbow height as the first significant predictor in the prediction of horizontal two handed reach when the work surface was lowered to 10 cm below the elbow height explained 20.33 per cent variation ( $R=0.452$ ). Nine variables joined the first significant predictor i.e., elbow height and the sizeable increase in multiple correlation was noted i.e., from 0.452 to 0.530 and to 0.560 with 7.55 and 3.17 per cent of additional variation in the criterion variable due to inclusion of abdominal circumference and arm length respectively. Subsequent addition of 7 variables accounted for less than 2 per cent variation. However, the total multiple correlation due to these additional nine variables to elbow height increased from 0.452 to 0.621. This increase was found to be higher when compared with elbow height in case of work surface 5 cm lower than the elbow height. The results were statistically significant at or beyond 0.05 level.

Normal two handed reach :

Variation in the normal two handed reach on the surface, close to the elbow height and 5 cm below the elbow height was explained by the eye height of the users. This was the only predictor variable entered in the stepwise regression analysis and also its multiple correlation and the percentage variation was found to be very low ( $R=0.156$ ,  $R^2=0.0227$  respectively) and was not significant. For the estimation of the same criterion variable on the surface 10 cm below the elbow height, no predictor variables entered the stepwise regression analysis. Therefore multiple regression was carried out and  $R^2$  was found to be  $-0.0202$ .

Maximum one hand reach :

For the estimation of maximum horizontal reach for one hand (right) at close to the elbow height, the first 4 predictor parameters viz., elbow height, abdominal circumference, arm span and functional reach-2, were found to be the major determinants out of 9 predictor variables. The total predicted variance due to these 4 variables was nearly 16.23 per cent (24.84 to 41.07 per cent) and multiple correlation ranged from 0.499 to 0.644. Further, succeeding five variables entered in order were arm length, eye height, hand length, forearm length and forearm circumference. These had marginally increased the multiple correlation to 0.669 with 43.85 per cent of the variance. The findings of stepwise regression analysis and multiple regression for the estimation of maximum horizontal reach for one hand (right hand) on the

surface at 5 and 10 cm below the elbow height respectively were not encouraging. Same can be taken for left hand.

Thus, based on the above data, it could be concluded that various maximum horizontal reaches on surface at different heights are mainly determined by the elbow height of an individual as it was found to be the best common predictor for horizontal reaches. Also it is clear from the stepwise regression analysis that, apart from the predictor variables under the study some other variables may also influence the criterion variables, which are not included in the present study (regression coefficients and constant values Table-70 in Appendix-9).

### SECTION-3

#### HOUSING DATA

Housing data collected from subsample of 100 households as per the selected criterion mentioned in the methodology is presented in this section. Housing data refers to the tenure of house, type of house and kitchen. In this section participation of homemakers and husbands in giving suggestions or specifications while building their house is dealt with. Housing background also deals with the problems faced by the homemakers related to designing of kitchen, storage, adequacy of kitchen layout and storage shelves dimensions. Data on housing conditions collected from the users are very essential and useful for the designers and

builders. It serves as feedback information to them and fill the gap between the users and designers.

TABLE : 23. Tenure of Housing of Respondents.

Status of housing	N=100	
	Frequency	percentage
TENURE : Own house	68	68.00
Rented house	32	32.00
RENT PAID/month (in Rs.)		
Less than 575.00	6	18.75
576.00 to 875.00	13	40.63
876.00 to 1075.00	10	31.25
1075.00 and above	3	09.37
Total		100.00
Mean rent paid	Rs. 810.94	
Standard deviation	245.18	

A high percentage of respondents lived in their own houses (68 per cent) and 32 per cent of respondents resided in rented houses (Table-23). Further, the analysis of rent paid showed that most of the tenants paid Rs 576.00 to Rs. 875.00 and Rs. 876.00 to Rs. 1075.00 as rent (40.63 per cent and 31.25 per cent respectively). The mean rent paid was Rs. 810.94 (SD=245.18).

TABLE : 24. Homemakers' participation in Giving Specifications for the Designing of Kitchen and Storage while Building their Own House.

Specifications by homemakers/others	N=68	
	Frequency	percentage
Specifications by the homemakers for kitchen and storage design	40	58.82
Specifications given by :		
Husband	9	32.14
Builder	17	60.72
Architect	2	07.14

The homemakers who were living in their own houses only 59 per cent stated their needs while building the kitchen and storage (Table-24). However, the percentage of participation is not encouraging because a good number of homemakers indicated negative response in giving specifications while constructing kitchen and storage (41 per cent). Among these houses, builders played a key role in deciding the kitchen and storage design (60 per cent). The role of husband was limited to only 32 per cent.

TABLE : 25. Types of Houses Occupied by the Respondents.

Types of houses	N=100	
	Percentage	
Independent	71.00	
Twin	17.00	
Two storeyed house	11.00	
Flat	01.00	
Total	100.00	

Seventy one per cent of the respondents were dwelling in independent houses (Table 25). It was observed in general that the housing in Dharwad comprises of independent houses. Eventhough the new housing construction is of multistoreyed building of flats still large number of families opt for independent houses. The remaining 29 per cent of homemakers' families lived in twin houses (17 per cent), in the two storeyed houses (11 per cent) and only one per cent lived in flats.

TABLE : 26. Types of Kitchens in the Selected Households.

Types of kitchens	N=100 Percentage
Independent kitchen	17.00
Kitchen combined with built-in storage shelves	78.00
Kitchen combined with dining hall	01.00
Kitchen combined with storage shelves and dining hall	04.00
Total	100.00

More than three-fourths (78 per cent) of respondents reported that their kitchen was combined with storage shelves (Table-26). About 17 per cent had independent kitchen, a negligible percentage had combined their kitchen with storage shelves and dining space.

Table 27. Problems Faced by Homemakers Regarding Existing Work counter in the Kitchen

Problems	N=100 Percentage
Length of work counter is short	51.00
Work counter is high and causes shoulder pain	26.00
Work counter is low and causes back pain	25.00
Depth of the work counter is more and require bending of body to reach the items	05.00
Depth of the work counter is narrow and cluttered	44.00

More than 50 per cent of housewives felt that the existing length of their work counter was short (Table-27). The depth of the counter space was found to be narrow and cluttered by 44 per cent. Twenty five per cent of the sample expressed that work counter in their house was either high or low, causing shoulder pain and back pain respectively. Only few respondents (5 per cent) revealed that the depth of the counter was more, as a result they had to bend forward to reach the items kept close to the wall.

TABLE : 28. Problems Faced by Homemakers Regarding Existing Storage.

Problems	N=100 Percentage
Total shelf height is beyond maximum reach and require raising of heels	34.00
Top shelf is high and require a step-stool to reach	24.00
Shelves under the work counter require body bending to reach the items stored	33.00
Shelves under the work counter require squatting to reach the items stored	06.00
Shelves under the work counter require both bending and squatting to reach the items stored	23.00
Shelves above the work counter are high and require raising of heels	07.00
Shelves above the work counter are high and require a stool to reach	06.00

The data showed discouraging picture of the existing storage condition (Table-28). The height of top shelf was not within the maximum reach of the user. Thirtyfour per cent of the respondents disclosed that they have to raise their heels to reach the top shelf. While 24 per cent of the housewives used a stool to reach the same. Scrutiny of the data of shelves under the work counter revealed a poor design and away from the convenient reach. In case of 33 per cent of the sample to reach stored items on the shelves under the counter required bending of the body. About 23 per cent of the women

indicated both bending and squatting on the floor to reach the items stored on the shelves under the counter. It was to be noted that the problems of shelves above the counter were reported by few homemakers (6-7 per cent). Again, the shelves above the counter were at a height and forced the users to raise their heels to reach the stored articles.

TABLE : 29. Problem Faced by Homemakers Regarding Existing Kitchen.

Problems	N=100 Percentage
Kitchen size is small	44.00
Front/back clearance space around work counter and storage area is not sufficient	60.00
Sink height is high and causes shoulder pain while washing	10.00
Sink height is low and causes shoulder and back pain while washing	31.00
Day light in the kitchen is not sufficient and artificial light is required while working	26.00
Kitchen lacks sufficient ventilation causing fatigue while working	26.00
Total	100.00

Kitchen is a place where a woman spends most of her time. It is her work place. Ergonomically designed work space is essential for her to enjoy work, to avoid health problems etc. The analysis of problems faced by homemakers regarding existing kitchen revealed that, kitchen size was small for 44 per cent of homemakers (Table-29). Sixty per

cent felt that the front/back clearance space around work counter and storage area was not sufficient. About 31 per cent of the sample expressed that they suffer from shoulder and back pain while washing dishes due to sink height which was found to be low. While, for 10 per cent of the housewives sink height was more and caused shoulder pain. Equal percentage (26 per cent) of respondents disclosed that day light and ventilation were not sufficient in their kitchen. As a result of this they had to use artificial light, lack of proper ventilation led to fatigue while working in the kitchen.

TABLE : 30. Opinions of the Respondents Regarding the Adequacy of the Work counter Dimensions.

Design of work counter	Opinions (N=100)		
	Percentage Yes	No	Total
Work counter height is at suitable height	54.00	46.00	100.00
Work counter depth is adequate	52.00	48.00	100.00
Work counter length is sufficient	46.00	54.00	100.00
Space around work counter and storage shelves is adequate	50.00	50.00	100.00

Homemakers were asked to give opinion regarding the adequacy of their existing work counter design. The recorded responses were Yes/No. It was indicated (Table-30) that, in more than 50 per cent of the households work counter height

was suitable and counter depth was adequate. However, the length of the counter was not adequate for 54 per cent of the sample. Fifty per cent of the respondents reported having adequate space around work counter and for storage.

TABLE : 31. Opinions of the Respondents Regarding the Storage Design.

Storage design	Opinions (N=100)		
	Percentage Yes	No	Total
Height of the top shelf is within maximum reach	51.00	49.00	100.00
Height of the lower shelf is within normal reach	38.00	62.00	100.00
Depth of shelf is suitable to store within the eye level	39.00	61.00	100.00
Depth of top shelves is within the maximum reach, items stored in single/double row can be reached conveniently	25.00	75.00	100.00
Shelves above the counter are within maximum reach (N=18)*	07.00	11.00	100.00
Shelves under the work counter are within the reach when the body is bent	36.00	64.00	100.00
Day light in the storage area is adequate	63.00	37.00	100.00
Design of the storage shelves is satisfactory	44.00	56.00	100.00

\*Not applicable to N = 82

Storage designing to the users requirements always facilitates the reaching of stored items conveniently. Ergonomically designed storage is the one which is built within the maximum and normal reach dimensions and also it

maintains the upright posture of the user. Scrutiny of the data (Table-31) indicated the positive and negative opinions of the sample regarding storage design in their houses. Not much variation was observed between 'Yes' and 'No' response of the homemakers with regard to the height of the top shelf. For 51 per cent it was within the maximum reach while it was beyond maximum reach for 49 per cent. Height and depth of the lower shelf, were not within the downward reach and not suitable to store the items, within the eye level (62 and 61 per cent respectively). Three-fourths of the sample could not reach the items stored in single or double row on the top shelf as the depth was more and beyond maximum reach. Data further showed that, few households (18 per cent) possessed the shelves above the work counter and among these 11 per cent were not within the maximum reach. The design of the shelves under the counter was very poor. Their height and depth was not even within the reach while bending for 64 per cent of the respondents. More than fifty per cent of the respondents reported that the day light in storage area was adequate and on the whole, the design of the storage shelves was not satisfactory (56 per cent).

TABLE : 32. Opinion of the Respondents Regarding the Kitchen Design.

Kitchen design	Opinions (N=100)		Total
	Percentage Yes	No	
Kitchen size is adequate	77.00	23.00	100.00
Day light in the kitchen is adequate	61.00	39.00	100.00
Ventilation in the kitchen is adequate	60.00	40.00	100.00
Overall design of the kitchen is satisfactory	51.00	49.00	100.00

Respondents were asked to give opinion on their existing kitchen design. Although earlier it was reported that small size kitchen was one of the problems for a sizable sample (44 per cent), a large number (77 per cent) of them opined that their kitchen size is adequate (Table-32). Day light and ventilation were adequate in the existig kitchen for more than 50 per cent of the respondents, for 51 per cent the overall design of the kitchen was satisfactory. But, 49 per cent were not satisfied with their overall kitchen design.

TABLE : 33. Respondents' Opinion on their Features of the Kitchen.

Kitchen features	Opinions (N=100)		Total
	Percentage Yes	No	
Location of kitchen light switch is within maximum reach	89.00	11.00	100.00
Location of kitchen light switch is in a safe place	88.00	12.00	100.00
Sink height is suitable to user's height	48.00	52.00	100.00

Further probe into the other features of the kitchen (Table-33), showed that for more than three-fourths of the sample, location of kitchen light switch was within the maximum reach and in a safe place. More than 50 per cent of the respondents revealed that the sink height was not suitable for them.

TABLE : 34. Opinion and Willingness to Give Suggestions for Better Kitchen Design.

Response	N=100 Percentage	
Ergonomically based work counter, storage construction should be designed	Yes	100.00
	No	-
Willingness to give suggestions for improvement in kitchen design	Yes	24.00
	No	76.00

Opinion of the respondents was sought regarding the consideration of user's body measurements while building work counter and storage shelves. The response was very encouraging. Cent per cent of sample were of the opinion that the counter and storage shelves should be built to suit the user's measurements (Table-34). Further probe showed that the willingness to give suggestions for the improvement of the kitchen design was discouraging. About one-fourth of the total sample came forward to suggest modifications or requirements for a better kitchen design.

Requirement of separate store room adjacent to the kitchen was felt and suggested by six respondents (Table-35). Another common suggestion was to reduce the depth of the storage shelves. Few housewives suggested a serving window in the kitchen and that kitchen size to be increased.

TABLE : 35. User's Suggestions for Improvements in the Kitchen Design.

Suggestions	N=24 Frequency
1. Work counter should be adjustable	1
2. Height of the work counter should suit the worker	2
3. To provide a serving window in the kitchen	3
4. To provide a separate store room adjacent to the kitchen	6
5. Window/s in the kitchen should be large	2
6. Level of the top shelf should be at convenient height	2
7. Kitchen size should be large	4
8. Depth of shelf should be reduced	2
9. To provide a shelf above the work counter	1
10. Complete glass window/s are preferable	1
11. Narrow loft in the kitchen is useless	1
12. Work counter length should be more	3
13. Length of the sink tap should be to the center of the sink	1
14. Shelves under the counter should not be at ground level	2
15. Depth of the shelves under the counter should be reduced	3
16. Sink should not be placed opposite to the kitchen door	1

SECTION-4  
EXISTING KITCHEN AND STORAGE

Kitchen activities demand a high degree of physical effort and with long working hours leading to fatigue. Major causative factors responsible for this is the poor design of the kitchen layout, kitchen shelves and work counter. Many times unsuitable kitchen shelves and work counter height leads to minor accidents like falls, dashing against the wall and burns etc. Therefore, it was felt that the documentation of data on existing condition of the kitchen is necessary. Based on this, recommendations may be framed for improvement of the future kitchen. The investigation results of existing kitchen and storage are presented in this section.

TABLE : 36. Percentage of Types of Kitchen Based on the Shape of the Work counter.

Types of kitchen	N=100 Percentage
'L' shaped	64.00
'U' shaped	04.00
Two wall	20.00
One wall	12.00
Total	100.00

Types of kitchen are classified mainly based on the arrangement of equipment, essential storage, work space, work counter components such as cooking, preparation and sink center. Sixty four per cent households possessed 'L' shaped

kitchen (Table-36). This was followed by two wall kitchen (20 per cent) and one wall kitchen (12 per cent). 'U' shaped kitchen was seen in very few households.

TABLE 37. Existing Kitchen size.

Kitchen size in sq. cm.	N=100 Percentage
Small kitchen ( <30908.91 sq. cm. or 3.09 sq.mt. )	2.00
Medium size kitchen (30908.91 sq. cm. to 160327.23 sq.cm. or 3.09 to 16 sq. mt)	98.00
Large size kitchen ( >160327.26 sq. cm. or >16 sq. mt.)	00.00
Total	100.00
Minimum size	21400 sq.cm (2.14 sq.mt)
Maximum size	149850.00 sq.cm (14.99 sq.mt)
Mean length	332.67 cm (3.32 mt)
Standard deviation	67.28
Mean Breadth	288.00 cm (2.88 mt)
Standard deviation	55.81
Mean kitchen size	95808.96 sq.cm (9.58 sq. mt)

Existing kitchen size of the sampled houses of Dharwad city revealed a better picture about the kitchen size (Table-37). Ninety eight per cent of the households had medium size kitchen ranging from 3.09 sq.mt. to 16 sq.mt. Mean length and breadth of the kitchen was found to be 3.32 mt. and 2.88 mt. respectively. The minimum size of the

kitchen was 2.14 sq.mt. and maximum size was 14.99 sq.mt. The size of the kitchen revealed the rectangular shape of the kitchen.

TABLE : 38. Location of Light Switch in the Kitchen.

Location	N=100 Percentage
Right side of the door	45.00
Left side of the door	39.00
Above the work counter	05.00
Outside the kitchen door	11.00
Total	100.00

In many households the kitchen light switch was located on the right side of the kitchen door (45 per cent) and it was observed on the left side of the door in 39 per cent of the households. However the location of switches on right or left side of door depends on the direction in which the door opens. This was followed by location of switch outside the kitchen door. Very few houses had inconvenient and unsafe location i.e., above the work counter.

TABLE : 39. Height of the Light Switch and Plug Point in the Kitchen.

Height of the light switch (cm)	Freq.	Per cent	N=100				
			Min.	Max.	Mean	SD	CV
From floor	95	-	80.00	185.00	159.33	12.81	0.080
Less than 155	29	30.53	-	-	-	-	-
156-175	60	63.15	-	-	-	-	-
176 and above	6	06.32	-	-	-	-	-
From work counter surface	5	-	160.00	184.00	-	-	-
Plug point height from the work counter surface	100	100.00	46.00	105.00	74.30	15.33	0.206

In majority of the houses (95 per cent) the light switches were located in a safe place (Table-39). The mean height from the floor to the switch board was 159.33 cm. When minimum and maximum height was examined it was found to be 80 and 185 cm respectively. In most of the households the height of the switch from floor ranged from 156 to 175 cm (63 per cent). About 30 per cent of the families had light switch less than 155 cm from the floor. Only five per cent reported the location of light switch above the work counter surface. Its minimum and maximum height was 160 and 184 cm respectively. Every household had a plug point facility over the work counter surface. The mean height of the plug point was 74.30 cm from the counter surface. The variation in height of plug point was about 20 per cent. The minimum plug point height from counter surface was recorded as 46 cm while maximum was 105 cm.

TABLE 40. Work counter Surface Finish in the Selected Households.

Work counter Finishing materials	N=100 Percentage
Ordinary stone	83.00
Granite stone	05.00
Cement	06.00
Red oxide	02.00
Ceramic tiles	04.00
Total	100.00

More than three-fourths of the sample had finished work counter surface with the ordinary stone viz., Kadapa stone (Table-40). Other types of materials used were granite stone (expensive), cement, red oxide and ceramic tiles in few houses.

The existing work counter length in the kitchen was classified as short, medium and long counters based on mean  $\pm$  1 standard deviation (Table-41). More than 50 per cent of the households (65 per cent) had medium length of the counter ranging from 223.66 cm to 475.76 cm. Short and long counters were existing in less than one fifth of the houses (17 and 18 per cent respectively). Their length ranged from less than 223.66 cm and more than 475.76 cm respectively. The average length of the work counter was found to be 349.71 cm and it ranged from 116.00 cm to 929.00 cm.

TABLE : 41. Length of the Existing Work counter in Kitchen.

Length of the work counter (cm)	N=100 Percentage
Short (Less than 223.66)	17.00
Medium (From 223.66 to 475.76)	65.00
Long (More than 475.76)	18.00
Total	100.00
Mean length of the work counter	349.71
Standard Deviation	126.05
C.V.	0.3604
Minimum length	116.00
Maximum length	929.00

TABLE : 42. Distribution of Households by work counter heights.

Work counter height (cm)	N=100 Percentage
Low (Less than 74.68)	13.00
Medium (From 74.68 to 86.38)	70.00
High (More than 86.38)	17.00
Total 100	100.00
Mean length of the work counter	80.53
Standard Deviation	5.85
C.V.	0.0726
Minimum height	65.00
Maximum height	95.00

Based on mean  $\pm$  1 standard deviation, the existing height of the work counters were classified as low (Less than 74.68 cm), medium (from 74.68 cm to 86.38 cm) and high counters (above 86.38 cm). In maximum number of households (70 per cent) the work counter was of medium height (Table-42). About 17 per cent of homemakers had high level counter and 13 per cent had low counter. The minimum and maximum height of existing work counter was 65.00 and 95.00 cm respectively. The mean height was found to be 80.53 cm.

TABLE : 43. Percentage of Depth of the Existing Work counter in the Households.

Work counter depth (cm)	N=100 Percentage
Narrow (Less than 53.44)	12.00
Medium (from 53.44 to 64.24)	76.00
Wide (More than 64.24)	12.00
Total 100	100.00
Mean depth of the counter	58.84
Standard Deviation	5.40
C.V.	0.0917
Minimum depth	43.00
Maximum depth	78.00

The work counter in the selected households were mainly of medium depth (53.44 cm to 64.24 cm). The observed percentage was 76 (Table-43). Equal percentage of (12 per cent) families had narrow depth (less than 53.44 cm) and wide depth counters (more than 64.24 cm). The mean depth of the counter was found to be 58.84 cm and the observed minimum depth was 43.00 cm and maximum was 78 cm.

TABLE : 44. Types of Shelves in the Kitchen.

Types of shelves	N=100 Percentage
Built-in open shelf	85.00
Built-in cupboard	09.00
Built-in wall cabinet	02.00
Movable shelf (Metal or Wooden rack)	04.00
Total	100.00

Regarding the existing types of storage shelves, built-in open shelves were prevalent in 85 per cent of families and nine per cent possessed built-in cupboard (Table-44). The built-in wall cabinets were in 2 per cent and moveable shelf in 4 per cent houses. These types of storage designs were present along with built-in open shelves in few houses and in others movable shelf was the only storage facility available.

TABLE : 45. Location of Storage Shelves in the Kitchen.

Location	N=100 Percentage
Above the work counter	13.00
Under the work counter	56.00
To the side or away from the work counter	85.00
Away from kitchen (Separate store room)	17.00

As regard the location of storage shelves in the kitchen more than 50 per cent of the families had storage facility under the work counter (Table-45). In many houses this facility was available along with other shelves located either to the side of counter, away from counter or away from kitchen. In many cases these shelves were left open. In majority (85 per cent) of the households the main storage shelves were located to the side or away from the work counter and these were mainly built-in open shelves (Table-41). Separate store room was possessed by only 17 per cent of the sample and also shelves above the counter were not that common as their percentage was only 13.

More than 50 per cent of the respondents possessed shelves under the work counter. The mean total height of the shelf was found to be 71.48 cm from the floor with minimum height of 30 cm and maximum of 196 cm (Table-46). The variation in the total height was traced to be 31 per cent. In many households (41 per cent) the total height of the shelf ranged from 70-79 cm followed by 60-69 cm (32 per cent).

Further, recording of subsequent shelf heights and depths indicated that, 48.20 cm and 55.63 cm were found to be the mean height and mean depth of the top shelf respectively. However, in 42 per cent of the homes, the height of the top shelf ranged from 30-39 cm and this was followed by 40-49 cm height in 37 per cent kitchens. Regarding the depth of the shelf it was found to be more, in more than fifty per cent of

TABLE : 46. Height and Depth of Shelves Under the Work Counter.

Height and depth (cm)	N=56						
	Freq.	Percentage	Min. cm	Max. cm	Mean cm	SD	CV
Total height :	56	-	30.00	196.00*	71.48	22.35	0.3126
Less than 59	8	14.29					
60-69	18	32.14					
70-79	23	41.07					
80-89 and above	7	12.50					
Top shelf height :			30.00	169.00*	48.20	23.23	0.4819
30-39	24	42.86					
40-49	21	37.50					
50-59	4	7.14					
60-69 and above	7	12.50					
Top shelf depth :			35.00	73.00	55.63	6.79	0.1220
Less than 49	10	17.86					
50-59	30	53.57					
60-69 and above	16	28.57					
Middle shelf height	9	16.07	28.00	137.00	-	-	-
Middle shelf depth	9	16.07	40.00	60.00	-	-	-
Bottom shelf height	7	12.50	25.00	54.00	-	-	-
Bottom shelf depth	7	12.50	40.00	60.00	-	-	-

\* Present in 1 or 2 houses only

the kitchens which ranged from 50-59 cm. Little more than one-fourth of the total sample (28 per cent) had even wider shelves. i.e., 60.69 cm depth. About one-fifth kitchens had middle and bottom shelves.

To conclude, the above result indicated that a shelf under the work counter was common among the selected households. It was partitioned with one shelf in many houses. The total height (31.26 per cent) and top shelf height (48.19 per cent) varied to a greater extent among the sample.

Measurements of shelves away or beside the work counter were analysed (Table-47). More than three-fourths of the respondents' households (85 per cent) storage shelf was present in the kitchen, either to the side of the work counter or away from work counter. The mean total height of the shelves was found to be 200.96 cm with a range of 150 and 300 cm. In 61 per cent of households the total height of the shelf ranged from 201.00 to 250.00 cm and which was more than the mean total height of the shelves. An examination of top shelves height revealed a range of 151-200 cm however, the mean height was 167.99 cm. While, investigating the availability of number of middle shelves, the data revealed that in all the families there was one middle shelf and second middle shelf was found only in 70 households (about 82 per cent). The mean heights of the second middle and third middle shelves were recorded as 123.36 and 91.71 cm respectively. But, the height of the first shelf ranged from

TABLE : 47. Height and Depth of Shelves Away or Beside the Work Counter.

Height and depth (cm)	N=85						
	Freq.	Percentage	Min. cm	Max. cm	Mean cm	SD	CV
<b>Total height :</b>	85	-	150.00	300.00	200.96	21.77	0.1083
Less than 150	3	3.53					
151-200	28	32.94					
201-250	52	61.18					
251 and above	2	2.35					
<b>Top shelf height :</b>	85	-	123.00	300.00	167.99	21.28	0.1266
Less than 150	9	10.59					
151-200	72	84.71					
201-250	3	3.53					
251 and above	1	1.17					
<b>Top shelf depth :</b>	85	-	20.00	68.00	33.68	9.87	0.2915
20-30	44	51.76					
31-40	23	27.06					
41-50 and above	18	21.18					
<b>Middle shelf height :</b>	85	-	30.00	250.00	123.36	30.91	0.2506
Less than 50	4	4.71					
51-100	5	5.88					
101-150 and above	76	89.41					
<b>Middle shelf height :</b>	70	82.35	26.00	150.00	91.71	26.15	0.2851
Less than 50	4	5.71					
51-100	43	61.43					
101-150 and above	23	32.86					
<b>Middle shelf depth :</b>	85	-	20.00	62.00	33.34	9.21	0.2763
20-30	41	48.24					
31-40	26	30.59					
41-50 and above	18	21.17					
<b>Middle shelf depth :</b>	70	82.35	20.00	66.00	33.24	10.22	0.3074
20-30	38	54.29					
31-40	17	24.29					
41-50 above	15	21.42					
<b>Bottom shelf height :</b>	74	87.05	8.00	100.00	60.28	23.17	0.3843
Less than 50	26	35.14					
51-100	48	64.86					
101-150 and above	-	-					
<b>Bottom shelf depth :</b>	74	87.05	20.00	62.00	33.50	8.49	0.2612
20-30	40	54.05					
31-40	20	27.03					
41-50 and above	14	18.92					

101-150 cm and above and the range of height of the second shelf was 51-100 cm. Measurement of lower shelf (bottom shelf) revealed the mean height of 60.28 cm the range being 51-100 cm.

Further, data on depth measurement, indicated that the depth of the shelves ranged from 20-30 cm, and the mean depth was 33 cm.

Thus, the above findings conclude that majority of the households had storage shelf with 2 shelves in the middle. Not much variation was noticed in the height and depth of the shelves.

Few households had either a shelf above the work counter or a shelf away from kitchen (separate store room) and movable (metal or wooden) shelf. Since sample size was less than thirty, only minimum and maximum height and depth of the shelves are presented in Table-48. About 13 households reported the presence of shelf above the work counter and its total height ranged from 72 to 140 cm. The minimum depth of the shelf was found to be 16-37 cm and maximum was 55 cm. Presence of separate store room was reported by 17 families. Out of 17 families only 13 houses had 2 middle shelves. The minimum and maximum total height was 109 cm and 208 cm respectively. The depth of the shelf ranged from 20 cm to 88 cm. Only four families possessed a metal or wooden shelf. The minimum total height was 126 cm while maximum was 204 cm. The depth of the shelf was between 15 to 40 cm. The minimum

height of the lower shelf was found to be 10 cm and maximum height was 90 cm.

TABLE : 48. Height and Depth of Kitchen Storage Shelves.

Height and depth (cm)	Frequency	Min. (cm)	Max. (cm)
Shelves above the counter :	13	-	-
Total height	-	72.00	140.00
Top shelf height	-	23.00	140.00
Top shelf depth	-	16.00	55.00
Middle shelf height	3	67.00	67.00
Middle shelf depth	-	37.00	55.00
Shelves away from kitchen :	17	-	-
Total height	-	109.00	208.00
Top shelf height	-	59.00	188.00
Top shelf depth	-	20.00	88.00
Middle shelf height	13	39.00	157.00
Middle shelf height	8	29.00	130.00
Middle shelf depth	13	20.00	88.00
Middle shelf depth	8	20.00	62.00
Bottom shelf height	10	45.00	96.00
Bottom shelf depth	10	20.00	88.00
Movable shelf :	4		
Total shelf height	-	126.00	204.00
Top shelf height	-	126.00	173.00
Middle shelf height	-	87.00	158.00
Middle shelf height	-	50.00	128.00
Bottom shelf height	-	10.00	90.00
Shelf depth	-	15.00	40.00

Analysis of different cooking appliances possessed by the respondents revealed that cent per cent of them had gas stove (Table-49). Among them, gas stove with stand were common (60 pr cent) which ranged from 15 cm to 19 cm (83 per cent). The lowest height of stove without stand was less than

TABLE : 49. Types of Cooking Appliances Possessed by Respondent's Families.

Types and dimensions (cm)	Frequency	Percentage	Mean SD Range (cm)
<b>Types :</b>			
Electric stove	12	12.00	9-12
Gas stove without stand	40	40.00	-
Gas stove with stand	60	60.00	-
<b>Dimensions :</b>			
Gas stove without stand :	-	-	12.29 2.46 7.50-17
Low height stove (Less than 9.83)	4	10.00	-
Medium height stove (From 9.83 to 14.75)	26	65.00	-
High stove (More than 14.75)	10	25.00	-
Gas stove with stand:	-	-	17.58 1.99 12-21
Low height stove (Less than 15.59)	4	06.67	-
Medium height stove (From 15.59 to 19.57)	50	83.33	-
High stove (More than 19.57)	6	10.00	-

15cm (6 per cent) while highest was 19 cm (10 per cent). The average height of the gas stove with stand was found to be 17.58 cm. Out of 40 per cent of the respondents, 65 per cent of them possessed medium height gas stove without stand and their height ranged from 9 cm to 14 cm. The height of low stove without stand was less than 9.83 cm and height of high stove was more than 14.75 cm. The average height was 12 cm. Along with gas stove 12 per cent of the families had electric stove. The height ranged from 9 cm to 12 cm. A good number of respondents possessed the stoves with height more than 19.57 cm.

TABLE : 50. Existing Number of Windows in the Kitchen of Selected Households.

Number of windows	(N=100) Percentage
No window	05.00
One window	95.00
Two windows	30.00

TABLE : 51. Mean Height and Breadth of Existing Windows in the Kitchen.

Size	N	Mean	SD	Min. (cm)	Max.	C.V
<b>Height :</b>						
Window-1	95	104.83	28.81	35.00	190.00	0.275
Window-2	30	102.56	28.11	59.00	151.00	0.274
<b>Breadth :</b>						
Window-1	-	123.35	40.08	27.00	248.00	0.325
Window-2	-	99.83	38.19	57.00	244.00	0.383

Ninety five per cent of the households had one window and 30 per cent had two windows (Table-50). About 5 per cent of the kitchens had not even a single window

Regarding the size of the window/s they were of different sizes (Table-51). The mean height of window-1 was 105 cm and window-2 was 102.56 cm. The mean breadth of window-1 was 123 cm and mean breadth of second window was 99.83 cm. Minimum and maximum height and breadth of window-1 were 35.00 and 190.00 cm, 27.00 and 248.00 cm respectively. Maximum and minimum height of window-2 were found to be 151 and 59 cm while maximum and minimum breadth were 244 and 57 cm respectively.

#### SECTION-5

##### EVOLVED STANDARDS AND SUGGESTED DESIGN OF KITCHEN LAYOUT

As an outcome of stepwise multiple regression analysis, stature was identified as the most contributing predictor variable to predict vertical two handed reach standing close to the wall and maximum shelf height reach with and without obstacle.

Also stepwise multiple regression indicated that various work surface heights were mainly determined by the elbow height of an individual.

Based on these findings vertical shelf height and horizontal reaches were further categorised with reference to stature and elbow height respectively into various percentile

groups from 5th to 95th percentiles. These were worked out to meet the individual differences for requirement of standards for designing of work counter and storage in the kitchen. This is necessary because designing of work counter and storage only for mean or average anthropometric and reach measurements do not meet the requirement of other groups of population who are below and above mean anthropometric and reach measurements.

A. Evolved standards for designing purpose :

Computed percentile values for various reaches in relation to stature and elbow height measurements were used for establishing standards for fixing of vertical fittings or carrying of activities that require vertical standing position, for designing of work counter and shelf height and depth in the kitchen.

a. Standards for vertical fittings :

The standards for vertical fittings in relation to stature are derived from vertical reaches. The standards are available for all percentiles i.e., from 5th to 95th percentile (Table-52). The standards are useful to decide the height of vertical fittings such as electrical fixtures, wall switches, wall brackets, wall fan, fixing certain utility or fancy articles (clock, photographs, kitchen plant stand) etc. Application of these suggested standards for the above mentioned purpose would facilitate easy reach, cleaning and operation of articles fixed on the wall.

TABLE : 52. Suggested Standards for Vertical Fittings in Relation to Stature Based on Vertical Reaches.

Vertical reaches	Percentiles	5th	10th	20th	30th	40th	50th	60th	70th	80th	90th	95th
Stature	(137.54)	(142.14)	(144.21)	(145.54)	(146.64)	(147.85)	(148.43)	(149.29)	(150.15)	(151.09)	(152.85)	(152.85)
							(cm)					
For maximum two hand reach fittings or work close to the wall	170.90	173.77	176.47	177.86	179.03	179.93	180.97	182.34	183.64	185.06	185.61	185.61
For maximum two hand reach fittings or work standing 15 cm away from wall	165.32	170.67	174.52	174.73	175.48	176.02	176.77	178.00	179.03	180.40	180.94	180.94
For maximum two hand reach fittings or work standing 30 cm away from wall	160.31	163.42	135.92	167.08	167.63	168.48	169.46	170.98	172.18	173.57	174.14	174.14
For downward reach fittings or work for right hand standing 15 cm away from wall	67.27	68.86	69.55	69.99	70.39	71.22	71.31	71.32	71.49	71.78	71.93	71.93
For upward reach for one hand (right) standing 15 cm away from wall	168.67	171.44	174.17	175.23	176.28	177.37	178.76	179.98	180.94	181.80	182.31	182.31
For normal two handed reach or work 15 cm away from wall	99.92	100.63	102.32	102.19	103.02	103.43	103.97	104.15	104.37	104.87	105.03	105.03
For normal two handed reach or work 30 cm away from wall	97.98	98.92	100.52	101.06	101.68	102.08	102.17	102.59	103.06	103.83	103.95	103.95

b. Standards for storage shelves in the kitchen :

These standards are evolved in relation to stature from the percentile distribution of shelf heights and depth reaches. The standards for various types of storage shelves in the kitchen are suggested for various percentile groups (Table-53). However application of these for designing of types of shelves is discussed only for 5th, 50th and 95th percentiles.

1. Built-in open shelves : For designing of built-in open shelves the total height of the shelves should not go beyond the maximum two handed reach standing close to the wall. For instance the total height of the built-in open shelves for 5th percentile should be 170.90 cm, for 50th percentile 179.93 cm and for 95th percentile 185.61 cm from floor (Table-53). Similarly the height of the top most and lower shelves should be within the height of 164.37, 67.28 cm (5th percentile), 172.46 cm, 71.11 cm (50th percentile), 177.25 cm, 72.78 cm (95th percentile) from floor respectively. The eye level or middle shelves should lie within the height of 133.21 cm (5th percentile), 140.24 cm (50th percentile) and 144.08 cm (95th percentile) from floor. Based on these measurements the available clearance space for 5th, 50th and 95th percentiles which is the difference between the top most shelf and eye level shelf i.e., 31, 32 and 33 cm and eye level shelf and lower shelf it is 66, 69, 71 cm respectively. Within this available space the user can plan and decide the number of shelves according to their requirements. However it is

TABLE : 53. Suggested Standards for Shelf height and Depth in Relation to Stature Based on Shelf Height and Depth Reaches.

Percentiles Stature	5th (137.54)	10th (142.14)	20th (144.21)	30th (145.54)	40th (146.64)	50th (147.85)	60th (148.43)	70th (149.29)	80th (150.15)	90th (151.09)	95th (152.85)
(cm)											
Shelf heights											
Total height of the shelf	170.90	173.77	176.47	177.86	179.03	179.93	180.97	182.34	183.64	185.06	185.61
Top 1st shelf height	164.37	166.27	168.72	170.29	171.51	172.46	173.31	174.48	175.57	176.75	177.25
Eye level shelf height	133.21	135.07	136.88	138.07	139.31	140.24	141.11	141.93	142.78	143.64	144.08
Lower shelf height	67.28	68.70	69.62	70.12	71.09	71.11	71.51	71.76	72.12	72.43	72.78
Top shelf height over the work counter	156.08	158.54	160.92	162.42	163.86	165.06	166.18	167.35	168.45	169.65	170.03
Top, middle shelf depth	15.79	15.92	15.94	15.98	16.00	16.03	16.09	16.13	16.29	16.35	16.49
Lower shelf depth	14.43	14.46	14.53	14.54	14.61	14.65	14.74	14.77	14.79	14.83	15.04
Shelf depth over the work counter	14.80	14.82	14.89	14.97	15.04	15.11	15.18	15.32	15.58	15.76	15.94
Total height of shelf under the work counter (work counter at elbow height)	19.92	20.00	20.78	21.48	21.59	22.79	23.69	24.29	25.54	26.63	28.89
Total height of shelf under the work counter (work counter at 5 cm below elbow height)	14.92	15.00	15.78	16.48	16.59	17.00	18.79	19.29	20.54	21.63	24.09

advisable to have more clearance space between the lower and middle last but one shelf to store big and heavy weight articles. Also downward one hand reach height measurement can be adopted to decide the lower shelf height as no variation was noticed between lower shelf height and downward one hand reach.

The depth of the top most and middle shelves should be 15-16 cm. Since not much variation was noticed in the depth reach measurements for various percentile groups one can be a little flexible in designing the depth of the shelves. This will facilitate to store the supplies in single row which is easy to handle.

2. Standards for projected storage shelves : Storage shelves against the wall or projected from the wall should be designed based on the suggested standards for upward and downward one hand reach standing 15 cm away from wall (Table-53). Designing for these standards also facilitate for maximum two handed reach standing at 15 and 30 cm away from wall. However standing 15 cm away from the wall should be considered as the 15 cm depth of the projected shelf. So that the user can stand close to the shelf to reach the supplies. Therefore, based on the above mentioned standards the total height of the projected shelf for 5th, 50th and 95th percentiles should be 168.67, 177.37 and 182.31 cm from floor and height of lower shelf should be 67.27, 71.22 and 71.93 cm from floor respectively.

3. Standards for shelves under the work counter : The design of the shelves or pullout drawers under the work counter should be within the standards of lower shelf height reach of a person. The total height of the shelf or pullout drawers under the work counter is based on the difference in measurement between work surface height at 5 cm below elbow height and lower shelf height reach. The standards for work counter height at 5 cm below elbow level for 5th, 50th and 95th percentiles were 82, 88 and 96 cm (Table-54) and for lower shelf it is 67.28, 71.11 and 72.78 cm (Table-53) respectively. Therefore, the total height of shelf or pullout drawers under the work counter should be within 15 cm for 5th percentile, 17 cm for 50th percentile and 24 cm for 95th percentile. However, the depth of the shelf or pullout drawers under the work counter will be in accordance with a depth of the work counter.

4. Standards for shelves or cabinet above the work counter : Standards for shelves or cabinet above the floor is based on the evolved standards for top shelf height over the work counter from floor (Table-53). Thus for 5th, 50th and 95th percentiles the total height of shelves or cabinets should be 156.18, 165.06 and 170.03 cm respectively from floor. However, minimum 30 cm clearance space should be maintained between the work surface and the lower shelf or the cabinet and it could be at the discretion of the users based on their requirement of the number of shelves.

c. Standards for work counter height and depth :

Standards for work counter height and depth are derived from the percentile distribution for horizontal reaches. It is worked out in relation to elbow height of the users (Table-54). It was felt that work counter height should be adjustable between elbow height and at 5 cm below elbow height, which will facilitate to carryout the activities such as kneading the dough, pounding, rolling etc. which require application of pressure. Based on this the work counter height should be at 5 cm below elbow height which is 82.20, 88.90 and 96.67 cm from floor for 5th, 50th and 95th percentiles respectively.

Near the cooking area a plank of 5 cm thickness and required length and depth equal to counter width may be mounted on the wall to provide the adjustable work surface at elbow level. This will facilitate carrying out of the activities such as cleaning of grains, cutting vegetables etc. which require elbow level height work counter.

The depth of work counter should be based on the one hand horizontal reach. This will facilitate carrying out even two handed tasks easily as one hand reach is always greater than two handed reach. As a result of this the depth of the work counter at 5 cm below elbow level for 5th percentile should be 37.50 cm, for 50th percentile 45.00 cm and for 95th percentile 53.83 cm.

TABLE : 54. Suggested Standards for Work Counter Dimensions in Relation to Elbow Height Based on Horizontal Reaches.

Percentiles	5th	10th	20th	30th	40th	50th	60th	70th	80th	90th	95th
Elbow heights	(87.20)	(88.70)	(90.40)	(91.60)	(92.68)	(93.90)	(94.80)	(95.80)	(97.30)	(99.06)	(101.67)
						(cm)					
Workcounter dimensions											
Work counter height at elbow height	87.20	88.70	90.40	91.60	92.68	93.90	94.80	95.80	97.30	99.06	101.67
Work counter height at 5 cm below elbow height	82.20	83.70	85.40	86.60	87.68	88.90	89.80	90.80	92.30	94.06	96.67
Work counter depth at elbow height	40.50	41.50	44.00	45.00	46.00	47.50	48.00	50.00	51.00	54.00	56.50
Work counter depth at 5 cm below elbow height	37.50	39.00	41.00	42.00	43.00	45.00	46.00	47.00	48.00	51.00	53.83

Fractions in the suggested standards could be rounded to nearest 1 cm while designing.

B. Suggested design for work counter and storage shelves in kitchen :

A modern kitchen is much more than merely food storage and place for cooking (Viswanathan, 1991), yet it is the most neglected space in the house.

Based on the data of existing kitchen and housing condition and evolved standards, a kitchen plan is illustrated for 5th percentile measurements (Fig.21 ). The size of the L-shaped kitchen is 300 cm x 360 cm. While planning the layout of the kitchen, problems reported by the respondents were taken into consideration. As discussed earlier the respondents were not ready to accept work counter height at elbow level or 5 cm below elbow level. They preferred a low level work counter in order to cope with the problem of working height while cooking on gas because it gets raised due to the height of gas stove mounted on a stand . This problem is taken care in the illustrated kitchen layout by lowering the height of the work counter by 30 cm with 30 cm length considering the average height of gas stove with stand (17.58 cm) and 12 cm height of prestige cooker (7.5 liter). A covering lid is provided to cover the cooking stove when it is not being used.

Another salient feature of the suggested plan is the adjustable work counter plank which is designed close to and

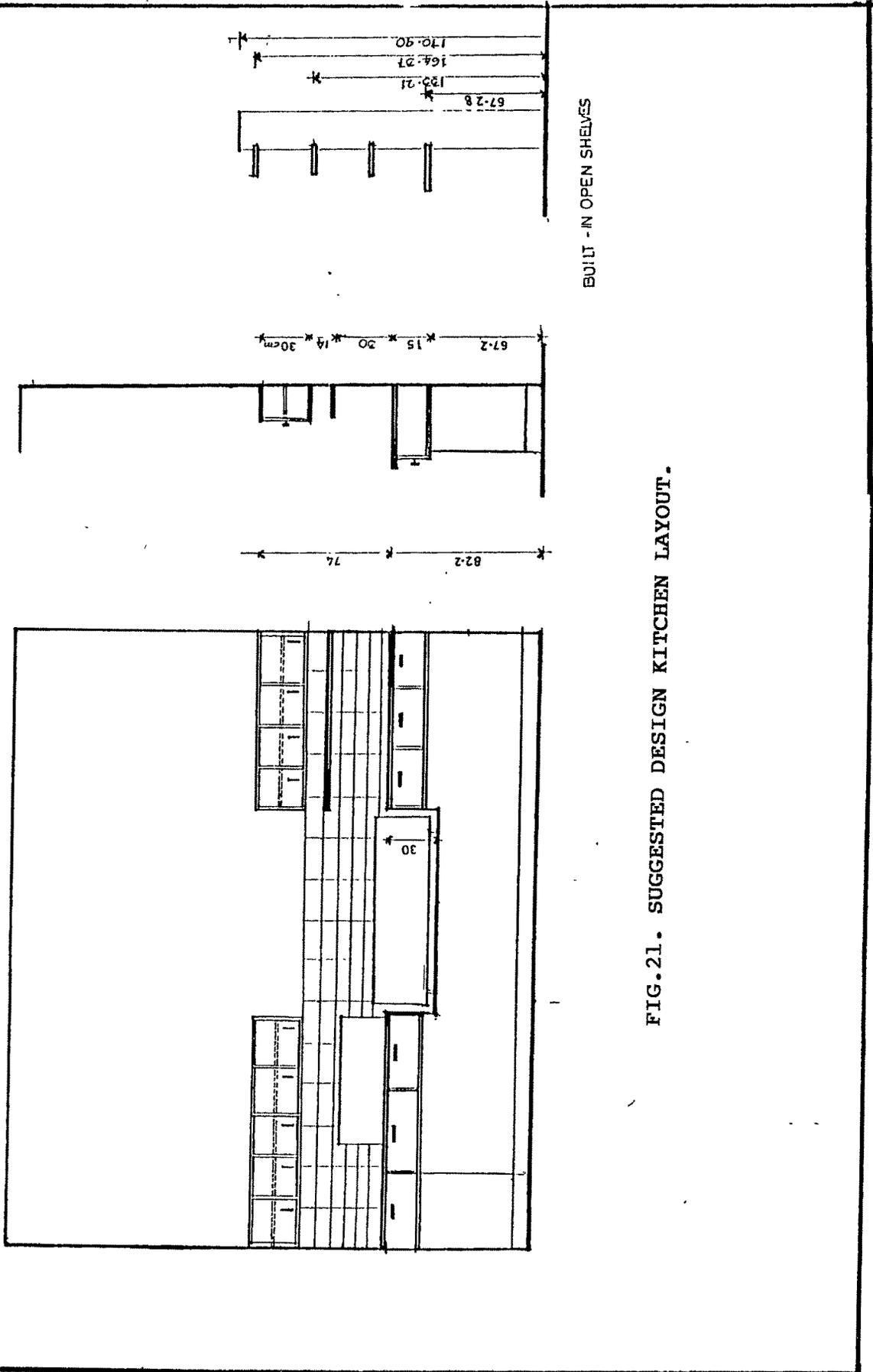


FIG.21. SUGGESTED DESIGN KITCHEN LAYOUT.

on the left side of the cooking area. This plank is vertically hooked to the wall. Whenever a worker needs to work on the work surface at elbow level she can release this plank from its vertical position and place it horizontally on the work surface. The dimension of the plank is 24 cm length, 37.50 cm width and 5 cm thickness.

Regarding the storage cabinet above the work surface, the total height is 74 cm from the work counter surface. However, these cabinets are designed 30 cm above the work surface and the total height of the cabinet is 44 cm.

The pullout drawers under the work surface will be ideal. Therefore, 15 cm height (according to 5th percentile measurement) drawer with sections is provided to store serving spoons, flat frying pan and other small articles.

The total height of built-in open shelves is 170.00 cm from the floor. The height of the top most shelf is 164.37 cm and lower shelf is of 67.28 cm from floor. Two rows of middle shelves are provided. The depth of the lower shelf is 20 cm and for other shelves it is 15 cm. This facilitates the storing of the big and heavy articles on the lower shelf.

Thus the illustrated kitchen layout plan could be considered as a functional plan as its design is based on the anthropometric measurement and reach of the user. Also it suggests the solution for some of the problems faced and reported by the respondents.

SECTION-6TESTING OF HYPOTHESES

The following specific null hypotheses were tested by employing appropriate statistical tests.

Hypothesis-1. There is no association between the anthropometric characteristics and the following background variables :

- a. Age of the respondent
- b. Marital status of the respondent
- c. Number of children
- d. Food habit

H<sub>1</sub>-a. Age of respondent :

Correlation regression analysis was carried out to study the relationship between age and anthropometric variables (Table-55). It depicted a negative relationship between age and most of the standing heights except upperarm length. But relationship was significant for stature ( $r=-0.160$ ), elbow height ( $r=-0.157$ ), Leg height ( $r=-0.122$ ), lower leg height ( $r=-0.132$ ) and eye height ( $r=-0.117$ ).

Age caused noticeable effect on girth measurements. The relationship was positive and significant at or beyond 0.05 level. The effect of age on abdominal girth was found to be high ( $r=0.538$ ), followed by bust ( $r=0.530$ ), and hip ( $r=0.526$ ). For upperarm, forearm and waist, the correlation co-efficients were less than 0.50.

## a. AGE OF THE RESPONDENT

TABLE : 55. Correlation Regression Analysis Between Age and Anthropometric Variables (N=526).

Anthropometric Variable (cm)		'r' values	Constant	Beta values	't' values
<b>Standing heights</b>	Stature	-0.160**	+155.59	-0.090**	3.71
	Arm span	-0.055 <sup>NS</sup>	+159.98	-0.040 <sup>NS</sup>	NS
	Right arm length	-0.062 <sup>NS</sup>	+ 69.01	-0.024 <sup>NS</sup>	NS
	Elbow height	-0.157**	+ 96.07	-0.066**	3.63
	Upperarm length	0.007 <sup>NS</sup>	+ 29.81	0.001 <sup>NS</sup>	NS
	Forearm length	-0.062 <sup>NS</sup>	+ 23.56	-0.018 <sup>NS</sup>	NS
	Hand length	-0.051 <sup>NS</sup>	+ 17.82	-0.006 <sup>NS</sup>	NS
	Leg height	-0.122**	+ 89.53	-0.073**	2.82
	Lower leg height	-0.132**	+ 44.97	-0.038**	3.04
	Eye height	-0.117**	+143.62	-0.068**	2.72
	Functional-1	-0.034 <sup>NS</sup>	+ 66.77	-0.013 <sup>NS</sup>	NS
	Functional-2	-0.035 <sup>NS</sup>	+ 65.78	-0.013 <sup>NS</sup>	NS
<b>Circumference Measurements (Standing)</b>	Bust	0.530**	+ 66.23	0.479**	14.31
	Upperarm	0.497**	+ 19.84	0.153**	13.11
	Forearm	0.426**	+ 19.56	0.090**	10.77
	Waist	0.496**	+ 54.43	0.502**	13.06
	Abdomen	0.538**	+ 66.00	0.625**	14.61
	Hip	0.526**	+ 79.59	0.548**	14.14

\*\* - Significant at 0.01 level

\* - Significant at 0.05 level

Thus it can be inferred from the results that the relationship between age and anthropometric characteristics is significant in both positive and negative directions. Therefore, the null hypothesis  $H_1$ -a was partially rejected for stature, elbow height, leg height, lower leg height, eye height and all circumferential measurements.

$H_1$ -b. Marital status of the respondent :

The effect of marital status on anthropometric parameters was studied by carrying out Analysis of Variance. The F-ratio for stature (4.47) and elbow height (5.10) were found to be significant at 0.05 level (Table-56) indicating the differences among marital status groups. For all circumference variables the effect of marital status was found to be significant at or beyond 0.05 level. The observed F-ratio for bust was 67.61, upperarm was 69.21, forearm was 61.74, waist was 62.24, abdomen was 77.76 and hip was 67.32.

Critical difference was calculated for the anthropometric characteristics for which F-ratio was significant to determine the difference within the three groups viz., married, unmarried and widow (Table-57). Married group differed from unmarried group in the stature measurement and these two groups did not differ from widow respondents. Similarly, for elbow height the variation between married and unmarried was observed and no difference was found between married and widow groups. But unmarried women showed variation in their elbow height when compared with widow

## b. MARITAL STATUS OF THE RESPONDENT

TABLE : 56. F-ratio for Effect of Marital Status on Anthropometric Measurements [N=526].

Anthropometric Measurements (cm)	N=384			N=134			N=8			F-ratio
	Married	Unmarried	Widow	Married	Unmarried	Widow	Married	Unmarried	Widow	
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Standing heights										
Stature	151.91	5.85	153.67	7.07	150.41	2.44				4.47*
Arm span	158.47	6.91	159.32	8.06	157.88	2.79				0.74NS
Right arm length	68.12	3.32	68.54	5.17	67.29	2.01				0.82NS
Elbow height	93.61	3.90	94.82	4.95	91.81	2.80				5.10*
Upperarm length	29.86	2.03	29.82	2.40	29.96	1.31				0.03NS
Forearm length	22.90	2.82	23.14	2.83	24.05	3.67				0.91NS
Hand length	17.63	1.19	17.62	1.32	16.84	0.57				1.64NS
Leg height	86.76	4.85	88.31	8.30	86.44	2.66				3.49NS
Lower leg height	43.61	2.79	44.15	3.03	42.45	2.39				2.56NS
Eye height	141.05	5.37	142.45	6.77	140.40	3.15				3.07NS
Functional-1	65.35	3.48	65.46	4.18	64.25	2.71				0.42NS
Functional-2	66.33	3.48	66.49	4.18	65.25	2.71				0.47NS
Circum-ference Measurements (Standing)										
Bust	84.25	8.30	75.01	7.25	87.88	8.53				67.61**
Upperarm	25.66	2.83	22.50	2.47	27.25	2.43				69.21**
Forearm	23.01	1.97	20.95	1.63	24.00	2.07				61.74**
Waist	73.39	9.81	63.41	6.57	78.00	9.96				62.24**
Abdomen	88.66	10.66	77.10	8.63	94.38	11.84				77.76**
Hip	97.20	9.68	86.62	7.94	102.50	11.24				67.32**

\*\* - Significant at 0.01 level

\* - Significant at 0.05 level

TABLE : 57. Critical Difference for Marital Status Groups on Anthropometric Measurements.

Anthropometric Measurements (cm)	N=384		N=134		N=8		CD-values		
	Married		Unmarried		Widow		1 Vs 2	1 Vs 3	2 Vs 3
	$\bar{X}$	$\bar{X}$	$\bar{X}$	$\bar{X}$	$\bar{X}$	$\bar{X}$			
Standing heights	151.91 <sup>a</sup>	153.67 <sup>b</sup>	150.41 <sup>ab</sup>				1.21	4.31	4.39
Elbow height	93.61 <sup>a</sup>	94.82 <sup>b</sup>	91.81 <sup>ac</sup>				0.42	2.93	2.98
Circumference - Bust	84.25 <sup>a</sup>	75.01 <sup>b</sup>	87.88 <sup>ac</sup>				1.58	5.63	5.74
Upperarm	25.66 <sup>a</sup>	22.50 <sup>b</sup>	27.25 <sup>ac</sup>				0.54	1.92	1.95
Forearm	23.03 <sup>a</sup>	20.95 <sup>b</sup>	24.00 <sup>ac</sup>				0.37	1.32	1.35
Waist	73.39 <sup>a</sup>	63.41 <sup>b</sup>	78.00 <sup>ac</sup>				1.79	6.37	6.79
Abdomen	88.66 <sup>a</sup>	77.10 <sup>b</sup>	94.38 <sup>ac</sup>				2.01	7.14	7.27
Hip	97.20 <sup>a</sup>	86.62 <sup>b</sup>	102.50 <sup>ac</sup>				1.83	6.50	6.63

Note : Common notations a b c in the table indicate non significant mean differences

respondents. Similar trend of differences between the groups with regard to all circumferential measurements was observed.

From the above findings it may be concluded that there was difference between marital status of the respondents and their anthropometric characteristics. However, the difference was only in stature, elbow height and in all six girth measurements. Within the three groups namely married, unmarried and widow, they showed variation in their anthropometric measurements. Unmarried sample differed from married and widowed. Hence, the null hypothesis  $H_1$ -b was partially rejected for stature, elbow height and all six girth measurements.

Details of Analysis of variance is presented in Appendix-10.

$H_1$ -c. Number of children :

With regard to the relationship of number of children and body dimensions a significant negative relationship with six standing height measurements and positive relationship with all circumference measurements were noticed (Table-58). They are as follows : For stature ( $r=-0.142$ ), elbow height ( $r=-0.146$ ), leg height ( $r=-0.112$ ) lower leg height ( $r=-0.109$ ) and eye height ( $r=-0.116$ ).

As number of children increased the selected girth measurements also advanced, the correlation value was above 0.383 and within 0.451.

## c. NUMBER OF CHILDREN

TABLE : 58. Correlation Regression Analysis Between Number of Children and Anthropometric Measurements (N=526)

Anthropometric Measurements (cm)		'r' values	Constant	Beta values	't' values
<b>Standing heights</b>	Stature	-0.142**	+ 6.73	-0.033**	3.28
	Arm span	-0.067 <sup>NS</sup>	+ 3.85	-0.013 <sup>NS</sup>	1.53
	Right arm length	-0.054 <sup>NS</sup>	+ 3.10	-0.020 <sup>NS</sup>	1.23
	Elbow height	-0.146**	+ 6.38	-0.049**	3.38
	Upperarm length	-0.005 <sup>NS</sup>	+ 1.85	-0.004 <sup>NS</sup>	0.12
	Forearm length	-0.043 <sup>NS</sup>	+ 2.24	-0.022 <sup>NS</sup>	0.99
	Hand length	-0.014 <sup>NS</sup>	+ 2.04	-0.017 <sup>NS</sup>	0.33
	Leg height	-0.112**	+ 4.10	-0.027**	2.59
	Lower leg height	-0.109**	+ 4.12	-0.054**	2.51
	Eye height	-0.116**	+ 5.79	-0.029**	2.66
	Functional reach-1	-0.008 <sup>NS</sup>	+ 1.94	-0.003 <sup>NS</sup>	0.18
	Functional reach-2	-0.005 <sup>NS</sup>	+ 1.86	-0.002 <sup>NS</sup>	0.11
<b>Circumference Measurements (Standing)</b>	Bust	0.442**	-3.99	0.070**	11.26
	Upperarm	0.432**	-3.24	0.200**	10.96
	Forearm	0.383**	-4.12	0.261**	9.51
	Waist	0.438**	-2.65	0.062**	11.17
	Abdomen	0.451**	-3.06	0.055**	11.55
Hip	0.441**	-3.99	0.061**	11.26	

\*\* - Significant at 0.01 level

\* - Significant at 0.05 level

Therefore, the null hypothesis  $H_1$ -c was partially rejected for stature, elbow height, leg height, lower leg height, eye height, and all six girth measurements.

$H_1$ -d. Food habit :

Analysis of variance was computed to study the effect of food habit on anthropometric characteristics. The variation 'between' the groups was found for a few of linear measurements and for more than 50 per cent of circumference measurements (Table-59). The difference was significant for stature ( $F=4.32$ ), elbow height ( $F=5.87$ ), forearm length ( $F=12.10$ ), leg height ( $F=4.64$ ), and lower leg height ( $F=7.37$ ). For girth measurements F-ratio was found to be significant for bust (4.77), waist (6.13), abdomen (8.09), and for hip circumference (5.83). The F-ratio indicated that there was no difference between vegetarian and non-vegetarian respondents for other linear heights viz., arm span, upper and forearm length, hand length, eye height, functional reaches. Also it was found to be the same for upper and forearm circumference.

Thus, it may be concluded that there was significant differences between vegetarian and non-vegetarian groups on the anthropometric characteristics.

Therefore the null hypothesis  $H_1$ -d was partially rejected for stature, elbow height, forearm length, leg height, lower leg height and circumference measurements viz., bust, waist, abdomen and hip.

## d. FOOD HABIT

TABLE : 59. F-ratio for Effect of Food Habit on Anthropometric Measurements [N=526].

Anthropometric Measurements (cm)	N=465 Vegetarian		N=61 Non-vegetarian		F-ratio
	$\bar{X}$	SD	$\bar{X}$	SD	
	<b>Standing heights</b>				
Stature	152.13	6.17	153.88	6.15	4.32*
Arm span	153.54	7.32	159.72	6.01	1.40 <sup>NS</sup>
Right arm length	68.22	3.59	68.21	5.52	0.00 <sup>NS</sup>
Elbow height	93.73	4.21	95.12	4.06	5.87*
Upperarm length	29.82	2.06	30.10	2.53	0.90 <sup>NS</sup>
Forearm length	22.83	2.48	24.16	4.64	12.10**
Hand length	17.58	1.21	17.86	1.31	2.81 <sup>NS</sup>
Leg height	86.95	6.09	88.68	4.23	4.64*
Lower leg height	43.61	2.89	44.66	2.46	7.37**
Eye height	141.28	5.75	142.32	5.80	1.76 <sup>NS</sup>
Functional reach-1	65.39	3.66	65.13	3.66	0.27 <sup>NS</sup>
Functional reach-2	66.37	3.66	66.19	3.67	0.13 <sup>NS</sup>
<b>Circumference Measurements (Standing)</b>					
Bust	82.26	9.15	79.59	7.51	4.77*
Upperarm	24.95	3.12	24.34	2.70	2.08 <sup>NS</sup>
Forearm	22.55	2.13	22.15	1.85	1.98 <sup>NS</sup>
Waist	71.31	10.37	67.92	7.19	6.13*
Abdomen	87.05	11.80	82.59	9.04	8.09**
Hip	94.98	10.55	91.57	8.66	5.83*

\*\* - Significant at 0.01 level

\* - Significant at 0.05 level

Details of analysis of variance is presented in Appendix-11.

Hypothesis-2 : There exists no significant interrelationship among various standing heights, sitting heights and circumferential measurements while standing.

The intercorrelation of anthropometric parameters are presented in three segments viz., intercorrelation among standing heights (Table-60a) sitting heights with themselves and other standing heights and circumference characteristics (Table-60b), lastly circumference girth with themselves and with other standing heights and sitting heights (Table-60c).

Most of the standing heights (Table-60a) were correlated among themselves at or beyond 0.05 level. Among these a high correlation of stature with arm span ( $r=0.832$ ), elbow ( $r=0.879$ ) and eye height ( $r=0.924$ ) was observed. The relationship of stature with remaining anthropometric characteristics had a sizeable positive significant relationship. The relationship of arm span with arm length ( $r=0.801$ ) and eye height was ( $r=0.811$ ).

All sitting heights (Table-60b) such as elbow height, sitting height and eye height had considerable correlation with all standing height measurements than circumferential girths. For the standing height measurements the 'r' value ranged between 0.30 to 0.60 and for the

TABLE : 60a. Intercorrelation Matrix of Anthropometric Variables (N=526).

Anthropometric Variables	Standing heights												
	1	2	3	4	5	6	7	8	9	10	11	12	
Standing Stature	1	-											
Arm span	2	0.832**	-										
Arm length	3	0.684**	0.801**	-									
Elbow height	4	0.879**	0.708**	0.596**	-								
Upperarm length	5	0.573**	0.681**	0.654**	0.462**	-							
Forearm length	6	0.358**	0.409**	0.453**	0.329**	0.503**	-						
Hand length	7	0.507**	0.583**	0.519**	0.438**	0.499**	0.391**	-					
Leg height	8	0.583**	0.510**	0.465**	0.631**	0.421**	0.342**	0.289**	-				
Lower leg height	9	0.609**	0.579**	0.468**	0.601**	0.430**	0.272**	0.337**	0.458**	-			
Eye height	10	0.924**	0.811**	0.674**	0.870**	0.545**	0.341**	0.508**	0.581**	0.610**	-		
Functional reach-1	11	0.638**	0.757**	0.644**	0.516**	0.577**	0.297**	0.533**	0.355**	0.520**	0.648**	-	
Functional reach-2	12	0.641**	0.759**	0.647**	0.520**	0.581**	0.294**	0.532**	0.357**	0.523**	0.652**	0.995**	-

\*\* - Significant at 0.01 level

\* - Significant at 0.05 level

TABLE : 60b. Intercorrelation Matrix of Anthropometric Variables (N=526).

Anthropometric Variables	Sitting heights										Standing heights										Circumference Measurements									
	14	15	16	12	11	10	9	8	7	6	5	4	3	2	1	17	18	19	20	21	22									
Sitting Elbow height	14	0.455**	0.546**	0.278**	0.278**	0.547**	0.382**	0.435**	0.244**	0.277**	0.294**	0.623**	0.401**	0.417**	0.539**	0.114**	0.138**	0.241**	0.020**	0.053**	0.154**									
heights	15		0.505**	0.469**	0.465**	0.618**	0.368**	0.377**	0.438**	0.248**	0.385**	0.162**	0.426**	0.542**	0.630**	0.074**	0.102**	0.177**	0.005**	0.047**	0.128**									
Sitting height	16			0.442**	0.439**	0.646**	0.429**	0.436**	0.373**	0.274**	0.397**	0.616**	0.494**	0.574**	0.644**	0.123**	0.094**	0.155**	0.033**	0.101**	0.152**									
Eye height																														

\*\* - Significant at 0.01 level

\* - Significant at 0.05 level

circumferential variables 'r' was less than 0.20. The interrelationship of the selected sitting heights was significant at or beyond 0.05 level with positive relation.

Both upper and lower trunk girth measurements (Table-60c) were highly correlated positively among themselves at or beyond 0.05 level of significance. Hip and bust circumference were highly ( $r=0.80$  and above) correlated with each other and with abdomen, bust, upperarm, waist and forearm. While, the range of correlation of abdomen with bust, waist and upperarm was 0.797 to 0.895. There was very little relationship between girth and standing height measurements. The relationship was both positive and negative but not significant in some cases and negligible in others.

Thus, standing height measurements were highly correlated among themselves. Sitting heights were more correlated with linear heights than girth measurements. Among circumferential parameters bust and hip measurements were highly correlated with other girths. Therefore, the null hypothesis-2 was rejected.

Hypothesis-3. The existing work surface and storage measurements in the kitchen do not differ from the standards evolved.

Low, medium and high level work counter heights were compared with the evolved standard workcounter heights based on different elbow heights of 5th, 50th and 95th percentiles

TABLE : 60c. Intercorrelation Matrix of Anthropometric Variables (N=526).

Anthropometric Variables	Circumference Measurements						Sitting heights						Standing heights								
	17	18	19	20	21	22	14	15	16	12	11	10	9	8	7	6	5	4	3	2	1
Circumf- Bust	-	0.838 <sup>***</sup>	0.747 <sup>***</sup>	0.632 <sup>***</sup>	0.895 <sup>***</sup>	0.899 <sup>***</sup>	0.114 <sup>***</sup>	0.074 <sup>NS</sup>	0.123 <sup>***</sup>	0.078 <sup>NS</sup>	0.079 <sup>NS</sup>	0.071 <sup>NS</sup>	-0.004 <sup>NS</sup>	-0.054 <sup>NS</sup>	0.022 <sup>NS</sup>	-0.007 <sup>NS</sup>	0.044 <sup>NS</sup>	0.062 <sup>NS</sup>	0.069 <sup>NS</sup>	0.135 <sup>***</sup>	0.065 <sup>***</sup>
erence Upperarm	-	-	0.863 <sup>***</sup>	0.733 <sup>***</sup>	0.797 <sup>***</sup>	0.837 <sup>***</sup>	0.138 <sup>***</sup>	0.102 <sup>NS</sup>	0.094 <sup>NS</sup>	0.040 <sup>NS</sup>	0.038 <sup>NS</sup>	0.063 <sup>NS</sup>	-0.027 <sup>NS</sup>	-0.061 <sup>NS</sup>	0.048 <sup>NS</sup>	0.041 <sup>NS</sup>	0.159 <sup>***</sup>	0.045 <sup>NS</sup>	0.077 <sup>NS</sup>	0.146 <sup>NS</sup>	0.065 <sup>NS</sup>
Measure- Forearm	-	-	-	0.636 <sup>***</sup>	0.668 <sup>***</sup>	0.768 <sup>***</sup>	0.240 <sup>***</sup>	0.177 <sup>***</sup>	0.155 <sup>***</sup>	0.119 <sup>***</sup>	0.116 <sup>***</sup>	0.149 <sup>***</sup>	0.048 <sup>NS</sup>	0.060 <sup>NS</sup>	0.144 <sup>***</sup>	0.054 <sup>NS</sup>	0.196 <sup>***</sup>	0.154 <sup>***</sup>	0.139 <sup>***</sup>	0.220 <sup>***</sup>	0.156 <sup>***</sup>
ments Waist	-	-	-	-	0.828 <sup>***</sup>	0.808 <sup>***</sup>	0.020 <sup>NS</sup>	0.005 <sup>NS</sup>	0.00 <sup>NS</sup>	0.030 <sup>NS</sup>	0.030 <sup>NS</sup>	0.019 <sup>NS</sup>	-0.049 <sup>NS</sup>	-0.128 <sup>***</sup>	-0.034 <sup>NS</sup>	-0.054 <sup>NS</sup>	0.083 <sup>NS</sup>	-0.022 <sup>NS</sup>	-0.004 <sup>NS</sup>	0.054 <sup>NS</sup>	-0.029 <sup>***</sup>
(Standing) Abdomen	-	-	-	-	-	0.931 <sup>***</sup>	0.055 <sup>NS</sup>	0.047 <sup>NS</sup>	0.101 <sup>NS</sup>	0.137 <sup>***</sup>	0.137 <sup>***</sup>	0.073 <sup>NS</sup>	0.007 <sup>NS</sup>	-0.110 <sup>NS</sup>	0.031 <sup>NS</sup>	-0.025 <sup>NS</sup>	0.137 <sup>NS</sup>	0.005 <sup>NS</sup>	0.052 <sup>NS</sup>	0.153 <sup>***</sup>	0.048 <sup>NS</sup>
Hip	-	-	-	-	-	-	0.154 <sup>***</sup>	0.128 <sup>***</sup>	0.152 <sup>***</sup>	0.125 <sup>***</sup>	0.125 <sup>***</sup>	0.126 <sup>***</sup>	0.022 <sup>NS</sup>	-0.025 <sup>NS</sup>	0.051 <sup>NS</sup>	-0.004 <sup>NS</sup>	0.152 <sup>***</sup>	0.093 <sup>NS</sup>	0.072 <sup>NS</sup>	0.176 <sup>***</sup>	0.106 <sup>***</sup>

\*\*\* - Significant at 0.01 level  
 \* - Significant at 0.05 level

(Table-61). The difference between low level counter and standards of work counter height at various elbow heights for all categories was found to be significant. There was no significant difference between the medium and high level counters and evolved standards of work counter height at 5 and 10 cm below elbow height for 5th and 95th percentiles respectively. For remaining groups and work counter at various elbow heights, the existing medium and high level work counter differed significantly at or beyond 0.05 level. Therefore, the null hypothesis-3 was partially accepted for medium and high level work counter for 5th and 95th percentiles in case of work counter height at 5 and 10cm below elbow height.

t-value were computed to test the differences between the standards evolved and the existing mean work counter depth namely narrow, medium and wide (Table-62). Except narrow depth counter (49.17 cm) for 50th percentile for maximum right hand reach at elbow height (47.50 cm) all other existing mean work counter depth differed significantly from the standards. The existing work counter depth was found to be greater than the standards.

Therefore, the null hypothesis-3, for existing depth measurements was partially accepted for narrow depth counter for 50th percentile group, for maximum right hand reach at elbow height. It was rejected for medium and wide depth counters for all percentile groups and right hand reach at various elbow heights.

TABLE : 61. t-Values Showing Differences in Existing Work Counter Height and Standards Evolved.

Variables and percentiles		WCH Standards based on Eh. (cm)	Existing Mean WCH (cm)		
			LLWC (70.85)	MLWC (80.06)	HLWC (89.88)
		t-values			
Work Counter at elbow height	5th	87.20	-21.33**	-14.97**	7.23**
	50th	93.00	-31.93**	-36.60**	-2.88*
	95th	101.67	-43.79**	-60.78**	-14.19**
Work Counter height at 5cm below elbow height	5th	82.20	-13.73**	0.53 <sup>NS</sup>	14.48**
	50th	88.90	-24.34**	-21.11**	4.36**
	95th	96.67	-36.19**	-45.28**	-6.94**
Work Counter height at 10cm below elbow height	5th	77.20	-6.14**	16.02**	21.72**
	50th	83.90	-16.74**	-5.61**	11.60**
	95th	91.67	-28.59**	-29.79**	0.30 <sup>NS</sup>
D.F.			12	69	16

Note : Workcounter height (WCH)  
 Low level workcounter (LLWC)  
 Medium level workcounter (MLWC)  
 High level workcounter (HLWC)

\*\* - Significant at 0.01 level

\* - Significant at 0.05 level

TABLE : 62. t-Values Showing Differences in Existing Work Counter Depth and Standards Evolved.

Variables and percentiles		WCD Standards based on MRHR at Eh (cm)	Existing NDWC (49.17)	Mean WCD (cm)	
				MDWC (58.87)	WDWC (69.00)
			t-values		
Work Counter at elbow height	5th	40.00	9.81**	76.01**	27.17**
	50th	47.50	1.79 <sup>NS</sup>	45.80**	20.14**
	95th	56.50	-7.84**	9.55**	11.71**
Work Counter height at 5cm below elbow height	5th	37.50	12.49**	86.08**	29.51**
	50th	45.00	4.46**	55.87**	22.49**
	95th	53.00	-4.98**	20.30**	14.21**
Work Counter height at 10cm below elbow height	5th	35.00	15.16**	96.14**	31.85**
	50th	43.00	6.60**	63.92**	24.36**
	95th	52.83	-3.92**	24.33**	15.15**
D.F.			11	75	11

Note : Workcounter depth (WCD)  
 Maximum right hand reach (MRHR)  
 Narrow depth workcounter (NDWC)  
 Medium depth workcounter (MDWC)  
 Wide depth workcounter (WDWC)

\*\* - Significant at 0.01 level

\* - Significant at 0.05 level

The existing total shelf height was compared with the standards of maximum vertical reach close to the wall (Table-63). The difference between these two was found to be significant at or beyond 0.05 level and existing measurement was higher than the standards. The mean height of existing top shelves was compared with top shelf height reach without elbow level obstacle. It revealed that the standards of 5th and 50th percentile did not differ significantly from the existing top shelf height. This was observed in 85 per cent of households. The 2nd and 3rd middle shelf height differed significantly (at or beyond 0.05 level) when compared with the standards of eye level shelf height. The measurements were lower than the standards. Existing lower shelf height also did not agree with the lower shelf height reach standards. It was found to be significant for 5th percentile, for 50th and 95th percentile groups at or beyond 0.05 level. Hence, the null hypothesis-3 for existing shelf heights was partially accepted for top shelf height for 5th and 50th percentiles with the respective standards. For other shelf heights namely total shelf height, 2nd, 3rd and lower shelf heights for all percentile groups it was rejected.

Comparison between existing shelf depth and standards showed that depth of the existing shelves was greater than the standards (Table-64). The differences of the depth of top, 2nd and 3rd middle and lower shelves compared with standards cited, were significant at or beyond 0.05 level for all percentile categories. Thus, the null hypothesis-3, for existing shelf depth was rejected.

TABLE : 63. t-Values Showing Differences in Existing Shelf Heights and Standards Evolved.

Variables and percentiles	SHR Standards based on stature (cm)	Existing Mean Shelf Height (cm)			t-values
		Total SH (200.96)	1st Top SH (167.99)	2nd MSH (123.36)	
Max. vertical reach close to the wall	5th	170.90			
	50th	179.93	12.66**		
	95th	185.61	8.85**	6.46**	
Top shelf height reach by placing the hand flat on a surface without obstacle	5th	164.37	1.56NS		
	50th	172.46	-1.92NS		
	95th	177.25	-3.99**		
Eye level shelf height	5th	133.21			
	50th	140.24	-2.92**		-13.18**
	95th	144.08	-5.01**	-6.14**	-15.42**
Lower shelf height reach by placing hand flat on a surface	5th	67.28			
	50th	71.11			-2.58*
	95th	72.78			-3.99**
					-4.67**
D.F					
		84	84	84	69
					73

Note : Shelf height reach (SHR)  
 Total shelf height (Tot. SH)  
 Middle Shelf height (MSH)  
 Lower shelf height (LSH)

\*\* - Significant at 0.01 level

\* - Significant at 0.05 level

TABLE : 64. t Values Showing Differences in Existing Shelf Depth and Standards Evolved.

Variables and percentiles	SDR Standards based on stature (cm)	Existing Mean Shelf depth (cm)			LSD. (33.50)	
		1st Top. SD (33.68)	2nd MSD (33.34)	3rd MSD (33.24)		
		t-values				
Top shelf depth reach by placing the hand flat on a surface without obstacle	5th	15.79	16.61**	17.46**	14.18**	
	50th	16.03	16.39**	17.23**	13.99**	
	95th	16.49	15.96**	16.77**	13.61**	
Lower shelf depth reach by placing the hand flat on a surface	5th	14.43			19.19**	
	50th	14.65			18.97**	
	95th	15.04			18.58**	
D.F.			84	84	69	73

Note : Shelf depth reach (SDR)  
 Shelf depth (SD)  
 Middle shelf depth (MSD)  
 Lower shelf depth (LSD)

\*\* - Significant at 0.01 level

\* - Significant at 0.05 level