

Original Research Article

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## Anthropometric Considerations for Hand Tool/Machinery Design for Chhattisgarh Female Workers of Raipur Districts, India

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### ABSTRACT

#### Keywords

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Anthropometric data of agricultural farm women is very essential for appropriate and efficient designing of farm machinery. This study revealed that anthropometric measurements of Chhattisgarh female farmers. The minimum, mean, and the maximum stature values are 146.3, 159.0, 174.6 cm for Female farmers respectively. The data was further analyzed and the efforts had been made to illustrate the applications of these measurements for designing and standardization of women friendly equipment. In the study, in addition to the descriptive values, 5th, 50th and 95th percentile values were also calculated.

### Introduction

Chhattisgarh has 7.48 million ha land under cultivation out of which 38.16 lakh ha land is under rice cultivation with rice production of about 57.89 lakh tonnes and with the productivity 1517 kg/ha during the year 2015-16 (Anonymous, 2016). Women do the most tedious and back-breaking tasks in agriculture, animal husbandry and at homes. Their contribution is very high in farm sector as they are involved in most of the farm operations and are, therefore, subjected to extra harsh conditions of work that lead to drudgery. Anthropometric dimensions vary considerably across gender, race and age. Within a

particular group also the anthropometry differs due to nutritional status and nature of work.

Thus to achieve better performance and efficiency along with higher comfort and safety to the operator, it is necessary to design tools, equipments and workplaces keeping in view of the anthropometric data of the agricultural workers.

It is very much essential for the designer to consider physical dimensions and human capabilities while designing farm equipments for better output and safety, because the man-machine interface decides the ultimate performance of the equipment.

## **Materials and Methods**

### **Measurement of body dimensions**

Anthropometric measurements were carried out on 30 female of different age group of Raipur district randomly chosen among hand hoe, hand operated paddy weeder, manually operated harvester, agricultural farm labours only. The age of the selected subjects varied from 22 to 50 years. Twenty seven measurements included bodyweight, stature, chest circumference, arm length, buttock political length, hip breadth (standing) etc. were selected from a farm machinery design point of view. The observations were taken carefully to measure all the dimensions in a correct posture and precise manner. Standing height (stature), bodyweight, hip breadth, etc. were measured in standing posture for that the subjects were asked to stand on a flat surface; their arms were adjusted according to their height, with their feet closed and their body vertically erected, while their heels, buttocks and shoulders touched the same vertical plane. The measurements were recorded from the vertical scale. An anthropological instrument (anthrop meter) was used for taking measurements with an accuracy of  $\pm 0.25$  mm.

Table 1, 2 and 3 gives anthropometric data of Chhattisgarh regions female farm workers, for the various body dimensions, which were considered to be useful in farm machinery design. Their respective estimates of mean, standard deviation, and coefficient of variation are also presented. The coefficient of variation is found maximum for the body weight.

The data were also analyzed for percentile distributions (5<sup>th</sup>, 50<sup>th</sup> and 95<sup>th</sup>) are presented in Table 1, 2 and 3. For design purpose, either one of the boundary values or the mean value is used. For boundary 5<sup>th</sup> and 95<sup>th</sup> percentile values are used and 5<sup>th</sup> percentile values would be used for design it will also take care

of 95% of the population. Thus, overall 90% of the population is taken into account and the 10% skipped population outside these boundaries were not take into account as they offer uneconomical.

### **Criteria for ergonomic design**

Design within the capability of a human worker.

Use of proper posture of the operator for most efficient performance of the tool at a lesser fatigue.

Suitability of the tool for workers of varying age and body dimensions.

## **Result and Discussion**

### **Anthropometric data of female farm labours**

The anthropometric data of three age groups of 30 female labour for the various body dimensions and the estimates of mean, standard deviation, coefficient of variation and percentile values (5<sup>th</sup>, 50<sup>th</sup> and 95<sup>th</sup>) are presented in table 1, 2 and 3 of different body dimensions and hand dimensions. The anthropometric data is taken as a guideline in designing the proper handle height, grip diameter, length of handles for getting more human comfort and better operational efficiency.

Table 1, 2 and 3 shows the percentile values of mean of three different age group (22-32, 32-42 and 42-50 years) of female workers for designing of hand tool machinery. Mainly shoulder height and elbow height were taken into consideration. Statistical data shows that variation among the females labour regarding these two parameters was very less. Hence mean value of shoulder height and elbow height 118.71, 123.06, 130.85 and 85.55,

93.68, 109.67 for 5<sup>th</sup>, 50<sup>th</sup>, and 95<sup>th</sup> percentile female workers of age group 22-50 were considered.

Percentile values of hand dimensions of female workers are presented in table 1, 2 and 3 hand dimensions are important for design of handle dimensions of the machine. Proper grip is required for effective force application while working with these tools. The 5<sup>th</sup>, 50<sup>th</sup> and 95<sup>th</sup> percentile values of grip diameter (inside) of female workers of Chhattisgarh Raipur were found as 2.42, 3.1 and 4.10 cm respectively. For a comfortable holding of the grip, the grip needs to be designed in such a way that a person with 5<sup>th</sup> percentile body

dimensions 2.5 cm able to properly grip the handle. Therefore, the minimum diameter of the grip should be for tool being operated by the female workers. Since variation among different labours was

This survey work set out to assist the development of more appropriately designed equipments, tools and agricultural machinery. The anthropometric survey was carried out on rural population in this respect to provide the better designed and modified agricultural equipments, tools and machinery by designers suiting to the human capabilities by using this survey data as a guide line for Chhattisgarh region (Fig. 1).

**Table.1** Percentile values of different body dimensions of female workers age group (22-32)

Parameters	Mean	Min	Max	5 <sup>th</sup>	50 <sup>th</sup>	95 <sup>th</sup>	SD	CV
Age (year)	28.3	22	32	22.4	29	32	3.65	0.12
Weight (kg)	44.4	37	56	37.4	44	53.3	5.96	0.13
Stature	150.1	146	157	146.4	150	155.65	3.31	0.02
Eye height	138.7	133.6	143	133.7	140	141.74	2.90	0.02
Shoulder	123.8	119	134	119	122.6	132.2	4.70	0.03
Elbow height	97.1	83	119	86.1	94	114.95	10.6	0.10
Hip height	88.3	83	92	83.9	89.2	91.1	2.68	0.03
Knuckle height	80.4	75	86	75	83	85.55	4.71	0.05
Knee height	44.1	39	47	40.0	45	46.55	2.39	0.05
Waist back length	31.9	27	42	27.09	30.5	41.1	5.20	0.16
Forward arm reach	68.3	66	70	66.4	68	70	1.26	0.01
Hip breath	32.3	24	43	25.3	30.9	40.3	5.62	0.17
Buttock knee height	78.8	76	82	76.9	79	81.1	1.53	0.01
Middle finger to elbow	42.2	38	44	38	43.7	44	2.55	0.06
Foot breath	9.9	8.7	11	9.0	10	10.64	0.57	0.05
Foot length	21.4	19	23.1	19.4	22	23.05	1.54	0.07
Hand length	17.9	15	20	15.9	18	19.5	1.4	0.08
Hand breadth at thumb	9.4	8	10.1	8.45	9.5	10.0	0.64	0.06
Grip diameter (inside)	3.4	2.5	4.5	2.5	3.2	4.2	0.69	0.20

All the dimensions are in cm, unless specified.

**Table.2** Percentile values of different body dimensions of female workers Age group (33-42)

Parameters	Mean	Min	Max	5 <sup>th</sup>	50 <sup>th</sup>	95 <sup>th</sup>	SD	CV
Age (year)	37.8	33	42	33.9	38	41.55	2.74	0.07
Weight (kg)	45.2	36	59	37.35	45.5	54.95	6.44	0.14
Stature	149.22	140	156	142.25	149.1	155.55	4.72	0.03
Eye height	139.48	133	145.8	133	140.5	145.44	5.01	0.03
Shoulder	124.5	115	130	118.15	124	130	4.52	0.03
Elbow height	94.52	83	99.2	85.25	96	99.11	5.41	0.05
Hip height	86.42	82	90.2	82.9	86	90.11	2.70	0.03
Knuckle height	77.9	73	83	74.35	77.5	83	3.14	0.04
Knee height	43.42	32	51	35.6	44	50.1	5.38	0.12
Waist back length	43.2	30	51	34.27	44.3	49.78	5.66	0.13
Forward arm reach	66.92	58	70	61.69	68	69.55	3.30	0.04
Hip breath	30.71	22	36	23.8	31.4	35.46	4.27	0.13
Buttock knee height	78.32	70.2	83.5	72.63	79.25	82.82	3.82	0.04
Middle finger to elbow	41.05	33.5	45.3	35.52	41.5	45.16	3.63	0.08
Foot breath	25.64	23	27	23.8	25.4	27	1.29	0.05
Foot length	8.21	6.4	10	6.44	8.25	10	1.62	0.19
Hand length	17.9	16	19.5	16.45	18.05	19.27	1.09	0.06
Hand breadth at thumb	9.16	8.2	9.7	8.56	9.2	9.61	0.40	0.04
Grip diameter (inside)	3.04	2.1	3.7	2.28	3.1	3.61	0.49	0.16

All the dimensions are in cm, unless specified.

**Fig.1**



**Table.3** Percentile values of different body dimensions of female workers Age group (43-50)

Parameters	Mean	Min	Max	5 <sup>th</sup>	50 <sup>th</sup>	95 <sup>th</sup>	SD	CV
Age (year)	48	45	50	45	49	50	2.26	0.04
Weight (kg)	51.7	39	67	41.7	51.5	63.85	8.15	0.15
Stature	148.51	143	159	143	147.4	156.75	5.28	0.03
Eye height	137.67	129	146	129.45	138	145.82	6.70	0.04
Shoulder	123.14	119	130	119	122.6	128.65	4.08	0.03
Elbow height	94.78	85.3	119	85.3	91.05	114.95	11.18	0.11
Hip height	86.87	80	97.2	81.35	85.15	95.31	5.21	0.06
Knuckle height	77.59	70.2	89.4	70.56	74.75	87.51	7.11	0.09
Knee height	43	38	48	38	42.15	47.415	3.41	0.07
Waist back length	41.76	30	45.5	34.5	42.75	45.32	4.60	0.11
Forward arm reach	71	68	78.2	68	69.85	76.85	3.37	0.04
Hip breath	32.36	27.6	39	28.23	32.5	38.1	3.77	0.11
Buttock knee height	78.98	76	83	76.045	79	82.55	2.42	0.03
Middle finger to elbow	44.36	42	50.1	42	43.65	48.34	2.57	0.05
Foot breath	34	28	41	28.45	34	40.1	4.16	0.12
Foot length	9.2	7.5	13	7.63	8.85	11.65	1.60	0.17
Hand length	17.5	15	20	15.67	17.45	19.55	1.46	0.08
Hand breadth at thumb	9.09	8	10	8.22	9.1	10	0.63	0.07
Grip diameter (inside)	3.3	2.5	4.5	2.5	3.1	4.5	0.79	0.23

All the dimensions are in cm, unless specified.

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