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Anthropometric Survey of Tribal Agricultural Worker of Eastern Hill and Plateau Region, India

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ABSTRACT

Most of the tribal farming community in Chhotanagpur plateau region of India use traditional tools in different agricultural operation. An anthropometric survey was conducted in order to minimize drudgery and increased the efficiency of tools. A total of 18 body dimension of 100 male and 100 female workers of farming activities were measured and analyzed for mean, standard deviation and percentile values. Measurement of body dimensions were taken in a standing posture and had higher for male subjects. Most of body dimensions for male workers of the region were lower than rest of India except north east and southern region. The data generated in the present study will be useful for design/redesign of various hand tools used by tribal farmers in the region.

Keywords: anthropometric dimensions, tribal workers, farm tools, hills and plateau

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INTRODUCTION

Chhotanagpur Plateau in eastern India covers Jharkhand and adjacent part of Odisha, West Bengal, Bihar and Chhattisgarh. The region is dominated with tribal community and primarily engaged in agriculture production system and wage activities for their livelihood (Sundaram *et al.*, 2019). Human/animal powers still dominated the tribal farming production system and often use mechanical power (Prasad, 2012). Traditional tools/technology of tribal farming community are mostly made up of bamboo, wood and iron as designed and articulated by the local artisans. Some of the progressive farmers also use standardized factory-made traditional implement that mostly economical. Traditional agricultural tools (spade, sickle, axe, *dao and desi* plough) of tribal are both used by men and women in farming operations i.e. land preparation, sowing, weeding, irrigation, harvesting, post-harvesting operation and transportation. Manually operated hand tools may be short or long-handled, may have push, pull/push-pull mode of operations. A typical hand tool/equipment consists of functional part, handle and a connecting part. Design of handle depends on mode of operation, handle material, handle length, grip diameter and anthropometric data of working population (Gite and Yadav, 1989). Many of researchers carried out anthropometric surveys in eastern India as mentioned in Table 1. One survey each by Gite and Yadav (1989) and Abood *et al.* (2015) have been carried out on adult male workers, tractor operators, farm mechanic and laborers of West India (Mumbai), north India (Punjab), central India (Bhopal) and north India (Allahabad) had the largest sample size of 1027 subjects whereas Gite and Yadav (1989) had the smallest sample of 39 among total surveys carried out in India. In order to achieve human comfort and increased efficiency of agricultural output, hence it is necessary to design of tools/equipment keeping in mind anthropometric details of workers of the region. The number of anthropometric surveys carried out in India is meager and dimensions included were specific to requirements. Gite and Yadav (1989) pointed out that there were considerable differences between the anthropometric features of Indians and Westerners. However, it does not contain any data related to tribal farmers of Chhotanagpur Plateau. Thus, it is necessary to establish an anthropometric data base of agricultural workers of the region for ergonomic design and modification of farm tools.

MATERIALS AND METHODS

An anthropometric survey was conducted during 2019-20 in the Eastern Plateau and hill region forms the northeastern part of the peninsular plateau of India and extends from 21°58' N to 25°18' N latitudes and 83°22' E to 87°57' E longitudes. The Chotanagpur plateau begins with the contour line of 150 m just south of Bihar plains and has average elevations varying from 308 to 924 m above the mean sea level. A total of 200 healthy farmers (100 male and 100 female) engaged in agricultural activities were randomly selected for the mentioned study. For efficient designing of the farm tools and implements for higher productivity, anthropometric data of operators are essential. Eighteen body dimensions were identified, and considered for design or redesign of hand tools and implements which are operated in standing posture.

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Table 1: Anthropometric surveys conducted in India by other authors

Surveys Conducted	n	Occupation	Age (yrs.)	No. of measurement	Region
Sen (1964)	40	Adult male workers	18-44	33	West India (Mumbai)
Pandey (1970)	75	Agricultural workers	16-55	11	East and south India
Guman singh *et al.* (1972)	100	Agricultural workers	18-70	11	East India (Odisha)
Sen *et al.* (1977)	192	Agricultural worker-102 Load handling labour-42 Industrial worker-48	15-40	29	East India
Gupta *et al.* (1983)	40	Tractor operators, farm mechanic and labourers	21-58	7	North India (Punjab)
Gite and Yadav (1989)	39	Farm workers	15-60	52	Central India (Bhopal)
Yadav *et al.* (1997)	134	Farm workers	NA	29	Eastern India
Dewangan *et al.* (2005)	280	Farm workers	20-30	33	North Eastern India
Agrawal *et al.* (2010)	1027	Male agri. workers-566 Female agri. Workers-461	19-51	34	North Eastern India (Meghalaya)
Majumder (2014)	147	Rural population	18-65	26	Eastern India (Odisha)
Abood *et al.* (2015)	100	Skilled tractor driver-50 Non tractor driver-50	40-45	28	North India (Allahabad)
Present study	200	Male-100 Female-100	20-60	20	Chotanagpur Plateau (Jharkhand India)

Body dimensions selected was in accordance with Hertzberg (1954). Anthropometric data i.e. age, weight, stature, eye height, shoulder height, elbow height, knuckle height, knee height, middle finger to elbow length, upper arm length, forward arm reach, elbow breadth, elbow height from base, elbow to elbow at forward hands, circumference at elbow, circumference at biceps, hand breadth, hand length, grip diameter and foot length were recorded (Figure 1). A portable stadiometer was fabricated for measurement of height. Two anthropometric scales of different length 1.0 and 1.5 m were fabricated to measure various body dimensions precisely. In addition, a Harpenden standard anthropometer (Holtain Ltd.UK) was used for taking bodily dimensions. Internal grip diameter was measured using a wooden cone specially designed for purpose. A portable weighing scale accurate to +50 g was used to take body weight. Data was presented in form of mean with SD, 5th and 95 percentile, which is pre-requisite for designing any ergonomically sound, user friendly tool and equipment. The body surfaces area (BSA) was calculated using DuBois and DuBois, (1916) equation.

Body surfaces area (BSA)= $(W^{0.425} \times H^{0.725}) \times 0.007184$ --------- (1)

Where, W= weight in kg and H= height in cm

Body mass index (BMI) of the subjects was also calculated using equation 2.

BMI = W/H^2 ---------- (2)

Where, W= weight in kg and H= height in m

Results and discussion

Anthropometric data for 18 body measurement of 100 male and 100 female agricultural workers of Chhotanagpur Plateau were measured, analyzed for mean, standard deviation and percentile values (Table 2 a, b). Mean age, weight and stature of tribal male agricultural workers (39.7 years, 54.8 kg and 156.1 cm) was significantly higher than that of female workers (35.7 years, 50.3 kg and 153.3 cm). Mean age, weight and stature of female workers were 9.88%, 5.04% and 1.77% lower than their male counterpart, respectively. Stature is an important dimension for its relevancy in determining several body dimensions. However, 5 and 95th percentile values of stature for male and female workers were found to be 156.1 cm and 153.3 cm, which suggest that design parameter, should not exceed this range making it otherwise cumbersome for user. Mean of elbow height, shoulder height, elbow breath, stature, hand length, middle finger to elbow, eye height, knuckle height, elbow height from base and knee height of female workers was less than their male counterparts by 0.15, 0.65, 1.77, 2.33, 2.40, 2.57, 3.28, 4.0 and 4.81% respectively. Circumference at elbow, palm breath at metacarpal, hand breadth, upper arm length, foot length, grip diameter of female worker were 5-7% less than male workers.

Forward arm reach and circumference at biceps were 9.83-10.34% lower for female workers and elbow to elbow at forward hands was observed to be 13.15% lower than male. Thus, implements often designed for male workers at other places in country, needs to be modified with suitable adjustment in handle length, working height, grip diameter. The present anthropometric data was compared to southern, central, north-eastern and northern India as presented in Table 3. Comparison of mean values reveal that stature, elbow height and knee height of both male and female subjects of Chhotanagpur region were smaller than southern, central, north eastern and northern Indian subjects. Eye height,

shoulder height and forward arm reach of the subjects were smaller than subjects of south, central and north India. Grip diameter was smaller than that of subjects of central, north eastern and northern India.

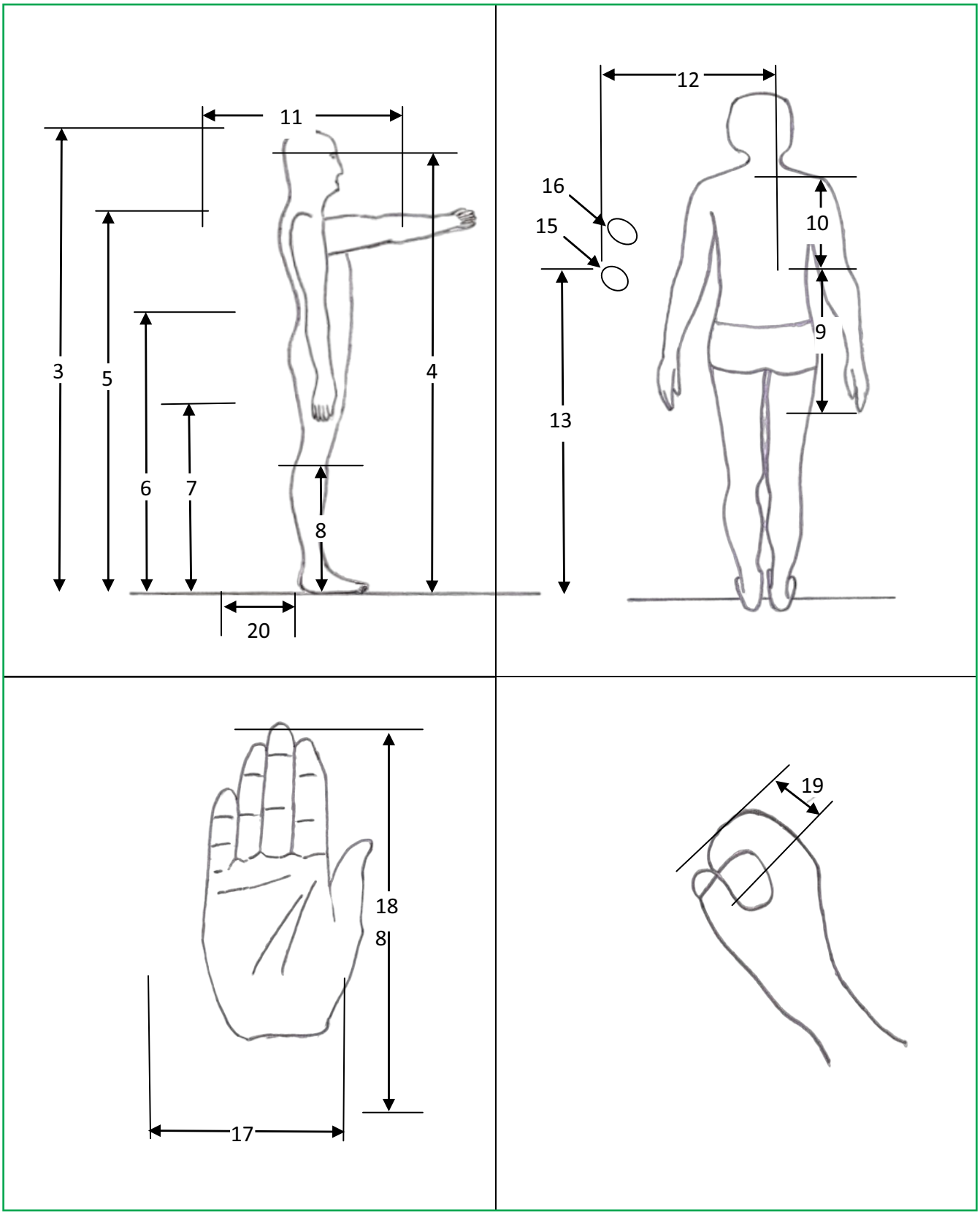

Fig. 1: Anthropometric dimension in standing posture (Gite and Chatterjee, 1999)

Table 2(a)**:** Anthropometric data of male agricultural workers in Chhotanagpur Plateau (N=100)

Sl. No	Anthropometric Measurements	Mean	SD	CV (%)	5th Percentile	95th Percentile
1	Age (yrs)	39.66	10.90	27.48	20.00	54.00
2	Weight (kg)	54.75	8.51	15.54	41.00	68.00
3	Stature (cm)	156.07	7.22	4.63	140.00	165.00
4	Eye height (cm)	146.48	8.33	5.69	126.00	156.00
5	Shoulder height (cm)	129.28	8.07	6.24	109	140
6	Elbow height (cm)	98.56	5.59	5.67	88.00	106.00
7	Knuckle height (cm)	89.61	5.67	6.33	80	98
8	Knee height (cm)	45.54	4.96	10.89	37	54
9	Middle finger to elbow (cm)	43.35	6.32	14.58	31.00	52.00
10	Upper arm length (cm)	31.93	5.81	18.20	21.00	45.00
11	Forward arm reach (cm)	70.2	7.51	10.7	58	80
12	Elbow breath (cm)	47.48	6.27	13.21	35	58
13	Elbow height from base (cm)	98.15	9.09	9.26	79.00	109.00
14	Elbow to elbow at forward hands	26.39	4.15	15.73	20.00	34.00
15	Circumference at elbow (cm)	23.63	3.53	14.94	18.00	29.00
16	Circumference at biceps (cm)	26.11	3.78	14.48	21.00	33.00
17	Palm breath at metacarpal (mm)/hand breadth	93.06	7.50	8.06	78.00	103.00
18	Hand length (mm)	176.99	8.14	4.60	161.00	190.00
19	Grip diameter (mm)	24.84	2.27	9.14	21.00	28.20
20	Foot length (cm)	25.36	2.10	8.28	22.00	29.00

Table 2(b)**:** Anthropometric data of female agricultural workers in Chhotanagpur Plateau (N=100)

Sl. No	Parameters	Mean	SD	CV (%)	5th Percentile	95th Percentile
1	Age (yrs)	35.74	7.96	22.27	24.00	51.00
2	Weight (kg)	50.26	8.86	17.63	37.00	64.00
3	Stature (cm)	153.31	8.35	5.45	143.00	168.00
4	Eye height (cm)	142.71	8.05	5.64	131.00	157.00
5	Shoulder height (cm)	129.08	4.88	3.78	121	136
6	Elbow height (cm)	98.46	5.04	5.12	90.00	108.00
7	Knuckle height (cm)	86.67	7.99	9.22	70	96
8	Knee height (cm)	43.35	6.23	14.37	31	51
9	Middle finger to elbow (cm)	42.31	4.57	10.80	34.00	49.00
10	Upper arm length (cm)	30.13	4.96	16.46	23.00	38.00
11	Forward arm reach (cm)	63.3	11.52	18.2	35	78
12	Elbow breath (cm)	47.17	11.19	23.72	35	76
13	Elbow height from base (cm)	94.22	7.81	8.29	78.00	103.00
14	Elbow to elbow at forward hands	22.92	4.62	20.16	17.00	31.00
15	Circumference at elbow (cm)	22.41	2.78	12.41	19.00	27.00
16	Circumference at biceps (cm)	23.41	4.32	18.45	15.00	30.00
17	Palm breath at metacarpal (mm)/hand breadth	88.22	8.55	9.69	75.00	104.00
18	Hand length (mm)	172.87	7.38	4.27	159.00	190.00
19	Grip diameter (mm)	23.21	2.04	8.79	20.00	27.00
20	Foot length (cm)	23.77	2.47	10.39	22.00	24.00

Hand breadth of male subjects was smaller than subject of north and north east India whereas female subjects were smaller than all comparing region. Hand length of both male and female and foot length of female subjects was smaller than subjects of central and northern India. Elbow to elbow at forward hands was smaller than north eastern subjects whereas circumference at elbow was smaller than subjects of central India. Both stature (156.07 cm and 153.31 cm for male

Table 3: Comparison of some mean values of earlier surveys from different parts of India

Body dimensions^	Chotanagpur Plateau		S. Indian[1]	C. Indian[2]	NE. Indian[3]	N. Indian[4]
	Male (n=100)	Female (n=100)				
Age (yrs)	39.66	35.74	-	-	-	-
Weight (kg)	54.75	50.26	-	49.3	53.7	58.44
Stature	156.07	153.31	160.7	162	161.4	163.76
Eye height	146.48	142.71	149.7	151	-	153
Shoulder height	129.28	129.02	130.1	134.6	-	138.05
Elbow height	98.56	98.46	98.90	102.6	101.4	102.6
Knuckle height	89.61	86.67	68.00			
Knee height	45.54	43.35	54.2	46.6	45.80	51.09
Middle finger to elbow	43.35	42.31	-	-	31	35.09
Upper arm length	31.93	30.13	-	-	-	-
Forward arm reach	70.2	63.3	73.20	83.1	-	83.51
Elbow breath	47.48	47.17	-	-	-	-
Elbow height from base	98.15	94.22	-	-	-	-
Elbow to elbow at forward hands	26.39	22.92	-	-	34.9	-
Circumference at elbow	23.63	22.41	-	38.4	-	-
Circumference at biceps	26.11	23.41	-	-	-	-
Hand breadth	9.306	8.822	9.7	10.2	9.1	7.97
Hand length	17.699	17.287	16.4	18.3	16.9	18.78
Grip diameter	2.484	2.321		2.8	4	5.15
Foot length	25.36	23.77	21.9	25	23.5	25.06

Source: [1]Fernandez and Uppugonduri (1992); 2 Gite and Yadav (1989); 3Agrawal et al (2010); 4Abood, et al (2015), All dimensions in cm except mentioned

and female, respectively) and weight (54.75 and 50.26 kg for male and female, respectively) of tribal farmers were lower and mean age was more than other countries (Table 4). Tribal farmers are shorter in height and have less weight than farmers in developing countries. The ratio of BSA to the body mass of agricultural workers of different nationalities was observed in ranges of 0.024-0.031. In our study, values are within range (0.028 and 0.029 for male and female, respectively). The results are in accordance with Bergmann rule, which states that body size of population increases with

Table 4: Anthropometric dimensions of farmers of different countries

Source	Nationality	n	Age (years)	Stature (cm)	Weight (kg)	BSA (m^2)	BMI (kg/m^2)	Ratio
Phillips (1954)	Nigerians	7	29	163.40	54.70	1.583	20.49	0.028
Manuba and Nala(1969)	Indonesians	5	35-60	161.60	54.80	1.571	20.98	0.028
Davies (1973)	Tanzanians	78	27	165.90	62.20	1.690	22.60	0.027
Spurr et al. (1975)	Columbians	59	18-56	163.80	58.60	1.633	21.84	0.027
Davies et al. (1976)	Sudanese	165	26	173.20	54.80	1.652	18.27	0.03
Maksud et al. (1976)	Columbians	55	29	163.00	57.80	1.618	21.75	0.027
Maksud et al.(1976)	Mexicans	15	22	166.70	71.00	1.794	25.55	0.025
Collins et al. (1976)	Sudanese	53	26	173.30	58.60	1.701	19.51	0.029
Demoulin and Chamla (1981)	Algerians	384	20-76	167.00	59.10	1.662	21.19	0.028
Pfeiffer *et al* (1984)	Canadians	105	48	174.40	80.20	1.953	30.71	0.024
Donati *et al*. (1984)	English	6	42	180.00	76.50	1.958	23.61	0.025
Smith *et al.* (1986)	Canadians	12	28	175.40	73.50	1.889	28.15	0.025
Intaranont *et al.* (1988)	Thai	100	20-49	162.80	55.20	1.585	20.83	0.028
Mokdad (2002)	Algerians	514	36	172.60	64.00	1.760	21.48	0.027
Present study	Indian-Male	100	39.66	156.07	54.75	1.532	22.48	0.028
	Indian-Female	100	35.74	153.31	50.26	1.459	21.38	0.029

decreasing mean temperature of habitat (Ciochon and Fleagle, 1993). BMI of Sudanese agricultural population was below normal range and that of Canadians was in obese range. BMI of subjects of all nationalities including that of present study were in normal BMI range (18.5-24.9). BSA of all subjects were in range of 1.5-2.0 m^2 except presently surveyed Indian female (1.459 m^2) of Chhotanagpur plateau region.

Hence, the outcome indicates that, females of Chhotanagpur have smaller height and lesser body volume compared to their counterparts in different parts of the world.

CONCLUSION

The following conclusions were drawn based on the results of this study:

- Anthropometric dimensions of male and female subjects of Chhotanagpur Plateau differ widely from rest of the India.
- Most of measurements taken in a standing posture are found to higher for male subjects.
- Most of body dimensions of male subjects of Chhotanagpur region are lower than other regions of India except the north eastern and southern region.
- BMI values of male and female subjects of study area are higher compared to Nigerians, Indonesians, Sudanese, Algerians, and Thai.
- In Chhotanagpur region, most of farming community was using traditional tool/equipment, which was not ergonomically designed. Thus, data generated in present study will be useful for refining existing traditional tool/equipments based on ergonomic considerations.

CONFLICT OF INTEREST

All the author both individually and collectively, affirms that they do not possess any conflicts of interest either directly or indirectly related to the research being reported in the publication.

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