

## Anthropometric Data of Agricultural Workers of Allahabad Region

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### Abstract:

*Anthropometry is fundamental to successful design of agricultural equipment. To achieve enhanced performance and efficiency of the man - equipment system along with better comfort and safety of the operator, it is necessary to design various agricultural tools, equipment and workplace, keeping into consideration the anthropometric data of agricultural workers. In this paper twenty-eight body dimensions, including the weight useful for designing new agricultural equipment and modifying existing agricultural equipment are selected. Hundred agricultural workers from 14 villages of Allahabad region were randomly selected. They were considered as a single group. Mean, standard deviation, 5<sup>th</sup>, 95<sup>th</sup> percentile, range, standard error, coefficient of variation, coefficient of correlation, the difference between 95<sup>th</sup> and 5<sup>th</sup> percentile for male agricultural workers of Allahabad region were computed. It can be seen that the mean stature of agricultural workers was 163.7 cm. The 5<sup>th</sup> and 95<sup>th</sup> percentiles of stature were 152.45 and 175.07 respectively. The mean weight of male agricultural workers was 58.04. The 5<sup>th</sup> and 95<sup>th</sup>*

*percentiles of weight of the agricultural workers were 40.96 and 75.91 kg respectively. Most of the selected body dimensions of subjects were correlated with stature significantly at 1 percent level of significance. These data could be used in designing new agricultural equipment and modifying existing agricultural equipment developed in other parts of the country and even other countries to suit human capabilities and limitations of agricultural workers in north India (Uttar Pradesh).*

**Key words:** Anthropometry; Tractor Seat design; Agricultural equipment design; Agricultural workers

## **Introduction**

Ergonomic dimensions match best to the orientation of the designed hardware which are recorded in different positions and postures that simulate the real working positions and postures in the conventional system (Yadav *et.al.* (2010)). Anthropometric data provides information on static dimensions of the human body in standard postures (Mohammad (2005)). In India, about 228 million workers are working in the agricultural sector. It is expected that the population of agricultural workers will be about 258 million in the year 2020, which is about 40% of the total number of workers (Ali (2008)). Around 150 million agricultural hand equipment and tools as well as above 3 million tractors are in use in Indian agriculture (Nag and Nag (2004)). The equipment includes manually-operated hand tools and machinery, animal drawn implements, tractors and other powered machinery. Agricultural hand tools and equipment are either operated or controlled by agricultural workers; therefore, anthropometric data is useful in designing new equipment and modifying existing equipment. Several anthropometric surveys were conducted in India but till now effort have not been made to collect anthropometric data of male agricultural workers of Allahabad, UP (Vyavahare and Kallurkar (2012)). The agricultural tractor driving requires the

operators to maintain a stable posture despite dynamic conditions. These requirements may involve a large number of turning movements from looking ahead to behind and vice versa resulting into a poor posture (Mehta *et.al.* (2008)). Keeping these points into consideration, anthropometric data on agricultural workers were identified, collected and analyzed to build the data bank.

## **Materials and Methods**

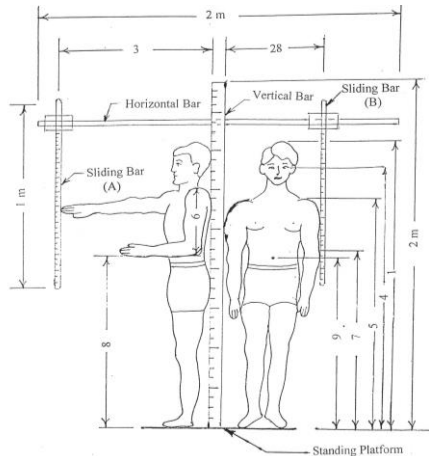
Hundred subjects (Fifty skilled tractor drivers and fifty non - tractor drivers) from the available Agricultural workers were selected from fourteen villages of Allahabad region. Their particulars including age were recorded. The subjects were in the age group of 20 – 45 years. Twenty-eight body dimensions, including the weight of the subject were selected for the study. These body dimensions were selected keeping into consideration the design requirements of hand tools, animal drawn equipment, tractors, power operated machines etc. and work place (Gite and Chatterjee (2000) These body dimensions are presented in Table1 and illustrated in Fig.1, Fig.2 and Fig.3. The selected body dimensions were measured using an anthropometer, vernier caliper, caliper, grip measuring device and a digital weighing machine. Most of the measurements were made with the subject in one of two postures: standing erect, or sitting erect. The two basic postures are described as follows:

- 1. Standing erect:** The subject stands erect, looking straight ahead (head in the Frankfort plane), heels together, weight distributed equally on both feet, and with his arms hanging naturally at his side (Fig.4).
- 2. Sitting erect:** The subject sits erect, looking straight ahead (head in the Frankfort plane), upper arms hanging relaxed, forearms and hands extended forward

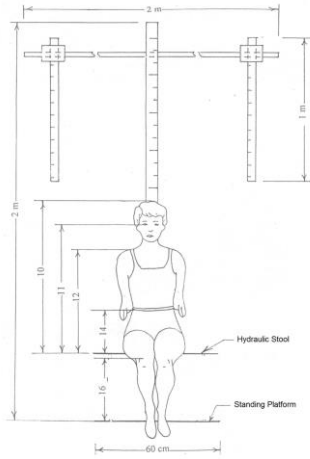
horizontally, thighs parallel, and the feet resting on a surface adjusted so that the knee are flexed 90° (Fig.5).

**Table 1 Selected Body Dimensions Useful in Agricultural Equipment Design**

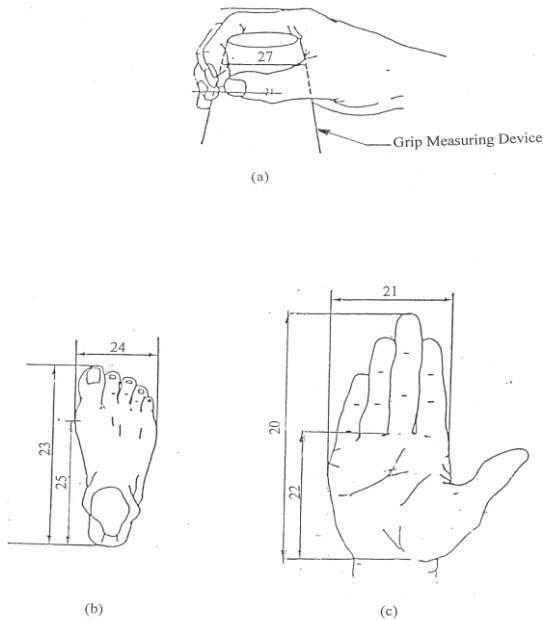
S.N.	Standing Posture	S.N.	Sitting Posture	S.N.	Miscellaneous Body Dimensions
1	Stature	10	Sitting height	20	Hand length
2	Weight	11	Sitting eye height	21	Hand breadth
3	Arm reach from the wall	12	Shoulder height	22	Palm length
4	Standing eye height	13	Elbow rest height	23	Foot length
5	Standing shoulder height	14	Waist height	24	Foot breadth
6	Elbow to shoulder length	15	Popliteal height	25	Instep length
7	Standing elbow height	16	Sitting Knee height	26	Hip breadth
8	Olecranon height	17	Elbow grip length	27	Grip diameter inside
9	Standing waist height	18	Buttock popliteal length	28	Shoulder breadth
		19	Buttock knee length.		



**Figure 1: Measurement of Body Dimensions in Standing Posture with an Anthropometer**



**Figure 2: Measurement of Body Dimensions in Sitting Posture with an Anthropometer**



**Figure 3: Measurement of Miscellaneous Body Dimensions**

## **Results and Discussion**

The selected body dimensions were collected, analyzed and presented in Tables 2, 3 and 4. Mean, standard deviation, 5<sup>th</sup> & 95<sup>th</sup> percentile, range, standard error, coefficient of variation, coefficient of correlation and the difference between 95<sup>th</sup> and 5<sup>th</sup> percentile for male agricultural workers of Allahabad region were computed. From Table 4.1, it can be seen that the mean stature of agricultural workers was 163.7 cm. The 5<sup>th</sup> and 95<sup>th</sup> percentiles of stature were 152.45 and 175.07. This suggests that while designing agricultural equipment, the design parameter should not exceed this range. The mean weight of male agricultural workers was 58.04. The 5<sup>th</sup> and 95<sup>th</sup> percentiles of weight of the agricultural workers were 40.96 and 75.91 kg respectively. Table 4.1 indicated that all body dimensions of subjects measured from standing position were correlated with stature significantly at 1 percent level of significance. The correlation coefficient ranged from 0.45 to 0.8. The coefficient of variation ranged from 3.75 to 18.18 percent. However coefficient of variation of weight was higher for male agricultural subjects as compared to other body dimensions.

Tractor and combine are usually operated from sitting position. Therefore sitting height, sitting eye height, sitting shoulder height, elbow rest height, sitting waist height, popliteal height, knee height, elbow grip length, buttock popliteal length and buttock knee length were measured. These body dimensions are presented in Table 4.2. The mean of sitting height of selected subjects was 78.53 cm. The 5<sup>th</sup> and 95<sup>th</sup> percentiles of sitting height were 73.07 and 83.99 cm respectively. The mean of the sitting eye height of selected subjects was 78.53 cm. The 5<sup>th</sup> and 95<sup>th</sup> percentiles of sitting height were 63.19 and 74.94 cm respectively. The mean of sitting shoulder height, elbow rest height, sitting waist height, popliteal height, knee height, elbow grip length, buttock popliteal length and buttock knee length of the subjects were

58.02, 19.55, 17.43, 42.08, 51.09, 35.09, 45.25 and 55.28 cm respectively. The 5th percentiles of these dimensions were 52.17, 14.81, 12.32, 37.9, 46.84, 32.32, 41.1 and 50.42 cm respectively. The 95th percentiles of popliteal height, knee height, buttock popliteal length and buttock knee length of the subjects need to be taken into consideration while designing seat dimensions of tractors, combines, etc. Whereas, the 95th percentiles of sitting shoulder height, elbow rest height, sitting waist height, popliteal height, knee height, elbow grip length, buttock popliteal length and buttock knee length of the subjects were 63.87, 24.28, 22.54, 46.26, 55.33, 37.86, 49.45 and 60.12 cm respectively. This suggests that while designing agricultural equipment and machines which have to be operated in sitting position, the design parameter should not exceed this range. Table 4.2 indicated that all body dimensions of subjects measured from sitting position were correlated significantly at 1 percent with stature except elbow rest height and sitting waist height. These dimensions were found non-significant. The correlation coefficient ranged from 0.1 to 0.58. The coefficient of variation ranged from 4.23 to 17.81 percent. However coefficient of variation of sitting waist height was higher for male agricultural subjects as compared to other body dimensions measured in sitting posture.

The man and machine interaction is through hand and foot. Therefore, dimensions of hand length, palm length, hand breadth, grip diameter (inside), foot length, foot breadth and instep length were measured and presented in Table 4.3. The mean hand length and foot length of male agricultural worker in this region were **18.78** and **25.06** cm respectively. The 5<sup>th</sup> percentiles of hand length, palm length, hand breadth, grip diameter (inside), foot length, foot breadth and instep length were 17.58, 9.45, 7.05, 4.49, 23.35, 8.47 and 17.32 cm respectively. Whereas, the 95<sup>th</sup> percentiles of these dimensions were 19.98, 11.47, 8.89, 5.8, 26.77, 10.77, 19.99 cm. These dimensions should be given due consideration while designing

hand and foot controls for agricultural machinery, for male operators. Table 4.3 indicated that all miscellaneous body dimensions were significantly correlated with stature at 1 percent level except foot breadth was significant at 5 percent level and hand breadth was non- significant. The correlation coefficient ranged from 0.18 to 0.48. The coefficient of variation ranged from 3.89 to 7.73 percent. However coefficient of variation of hip breadth was higher as compared to other miscellaneous body dimensions.

### Conclusion

Thus, the study presents a useful compilation of the selected anthropometric data of male agricultural workers of the Allahabad region. These data could be used in designing new agricultural equipment and modifying existing agricultural equipment developed in other parts of the country and even other countries to suit human capabilities and limitations of agricultural workers in north India (Uttar Pradesh). Further taking into consideration the range of 5<sup>th</sup> and 95<sup>th</sup> percentile of the selected body dimensions, adjustable design could be made and range of adjustments may be provided.

**Table 2 Anthropometric Data of Agricultural Workers of Allahabad Region Measured in Standing Posture**

S.N	Body dimensions	Mean	S.D	Range	CV%	5 <sup>th</sup> Percentile	95 <sup>th</sup> Percentile	95 <sup>th</sup> percentile - 5 <sup>th</sup> percentile	Correlation with stature	Std. Error of Mean
1	Stature †	163.76	6.88	150-186.5	4.20	152.45	175.07	22.62	1	0.688
2	Weight (kg)	58.44	10.62	41.7 - 83	18.18	40.96	75.91	30.1	0.450**	1.062
3	Arm reach from the wall	83.51	3.33	76.5 - 93	3.98	78.18	89.12	10.82	0.577**	0.333
4	Standing eye height	153.00	5.98	141 - 168	3.91	143.16	162.83	19.67	0.801**	0.598
5	Standing shoulder height	138.05	5.81	126.5 - 158.5	4.21	128.50	147.61	19.11	0.756**	0.581
6	Elbow to shoulder length	33.52	1.65	28.5- 37	4.93	30.80	36.24	5.44	0.496**	0.165
7	Standing elbow height	102.60	3.75	94- 112.7	3.75	96.27	108.93	12.66	0.665**	0.385
8	Olecranon height	101.13	4.17	92 - 113.5	4.12	94.27	107.99	13.79	0.645**	0.417
9	Standing waist height	102.95	4.47	92.5 - 115.3	4.34	95.59	110.31	14.20	0.682**	0.447



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+ All body dimensions are in cm except weight in Kg.

\*\* Correlation significant at the 0.01 level (2-tailed)

\* Correlation significant at 0.05 level (2-tailed)

**Table 4.2 Anthropometric Data of Agricultural Workers of Allahabad Region Measured in Sitting Posture**

S.N	Body dimensions	Mean	S.D	Range	CV%	5 <sup>th</sup> Percentile	95 <sup>th</sup> Percentile	95 <sup>th</sup> percentile - 5 <sup>th</sup> percentile	Correlation with stature	Std. Error of Mean
1	Sitting height	78.531	3.32	70-86	4.23	73.07	83.99	10.92	0.58**	0.332
2	Sitting eye height	69.062	3.57	58.5 - 79	5.17	63.19	74.94	11.75	0.441**	0.357
3	Sitting shoulder height	58.02	3.56	47.5 - 68	6.13	52.17	63.87	11.7	0.43**	0.356
4	Elbow rest height	19.55	2.88	13 - 32	14.72	14.81	24.28	10.27	0.1	0.288
5	Sitting waist height	17.43	3.10	12.2 - 26	17.81	12.32	22.54	10.21	0.151	0.310
6	Popliteal height	42.08	2.54	35 - 55	6.04	37.90	46.26	8.36	0.399**	0.254
7	Knee height	51.09	2.58	43 - 55	5.05	46.84	55.33	8.5	0.615**	0.258
8	Elbow grip length	35.09	1.69	32 - 38	4.81	32.32	37.86	5.55	0.531**	0.169
9	Buttock popliteal length	45.28	2.54	41 - 52.3	5.61	41.10	49.45	8.40	0.569**	0.254
10	Buttock knee length	55.28	2.94	49 - 65.5	5.32	50.42	60.12	9.73	0.648**	0.294

\*\* Correlation significant at the 0.01 level (2-tailed)

\* Correlation significant at the 0.05 level (2-tailed)

**Table 4:3 Miscellaneous Anthropometric Data of Agricultural Workers of Allahabad Region Measured in Standing Posture**

S.N	Body dimensions	Mean	S.D	Range	CV%	5 <sup>th</sup> Percentile	95 <sup>th</sup> Percentile	95 <sup>th</sup> percentile - 5 <sup>th</sup> percentile	Correlation with stature	Std. Error of Mean
1	Handle length	18.78	0.73	17- 20	3.89	17.58	19.98	2.40	0.45**	0.073
2	Hand breadth	7.97	0.56	6.8- 10.5	7.03	7.05	8.89	1.84	0.19	0.056
3	Palm length	10.46	0.62	8.5 - 11.5	5.89	9.45	11.47	2.03	0.379**	0.062
4	Foot length	25.06	1.04	22.3 - 27.5	4.14	23.35	26.77	3.42	0.48**	0.104
5	Foot breadth	9.62	0.70	8.10 - 11.3	7.25	8.47	10.77	2.32	0.297*	0.070
6	Instep length	18.66	0.81	16.5 - 20.5	4.34	17.32	19.99	2.67	0.402**	0.081
7	Hip breadth	29.80	2.30	26 -42	7.73	26.01	33.58	7.58	0.306**	0.230
8	Grip diameter	5.15	0.40	4 - 6	7.72	4.49	5.80	1.31	0.394**	0.040

\*\* Correlation significant at the 0.01 level (2-tailed)

\* Correlation significant at the 0.05 level (2-tailed)

## **REFERENCES**

- Ali, N. (2008). Farm mechanization: status, policies and issues. In: Singh, S. (Ed.), Proceedings of Tractor and Machinery Manufacturer's Meet. Central Institute of Agricultural Engineering, Bhopal, India : 29-46.
- Gite, L. P. and D. Chatterjee (2000). Proposed Action Plan on All Indian Anthropometric Survey of Agricultural Workers. AICRP on Human Engineering and Safety in Agricultural, CIAE Bhopal.
- Mehta, C.R., L.P. Gite, S.C. Pharade, J. Majumder and M.M. Pandey (2008). Review of Anthropometric Considerations for Tractor Seat Design. *International Journal of Industrial Ergonomics* 38 (2008) 546-554
- Mohammad, Y.A.A. (2005). Anthropometric characteristics of the hand based on laterality and sex among Jordanian. *International Journal of Industrial Ergonomics* 35 (1): 747-754
- Nag, P.K., Nag, A. (2004). Drudgery, accidents and injuries in Indian agriculture *Industrial Health* 42 (4):149-162.
- Vyavahare, R. T. and S. P. Kallurkar (2012). Anthropometric and Strength Data of Indian Agricultural Workers for Equipment Design: A Review. *Agric Eng Int: CIGR Journal* 14(4): 102-114
- Yadav, R., S. Pund, N.C. Patel and L.P. Gite (2010). Analytical Study of Strength Parameters of Indian Farm Workers and its Implication in Equipment Design. *Agricultural Engineering International: the CIGR Ejournal*. Manuscript MES 1538 . 7(1):1-8