Anthropometric Measurements and Grip Strength of Western Maharashtra Agricultural Workers

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Abstract- Anthropometric data of agricultural workers is very essential for designing farm equipments. The purpose of this paper is to analyze sixty four anthropometric body dimensions of the agricultural workers of the western Maharashtra. A survey of convenience sample of 61 male agricultural workers was conducted in 2013. Paper contains anthropometric data from four districts of western Maharashtra state of India. The economic growth and technological improvements have lead to greater demand and development of machines and devices used in industrial settings. With these dramatic changes there has also been greater interaction between man and machines. Anthropometric data are one of essential factors in designing machines and devices.

Keywords – Anthropometry, Ergonomics, Farm Equipments, Western Maharashtra

I. INTRODUCTION

Anthropometric data are one of essential factors in designing machines and devices. More and more hand tools, implements and machines are developed, manufactured and used for various agricultural operations in Indian agriculture. The size, design and dimensions of these tools and implements have a great bearing on the size and physical built of the users. Therefore compatibility between the two is essential. The only way to fulfill this objective is to create a database of anthropometric dimensions of the user population. Ergonomic dimensions correspond best to the orientation of the designed hardware which is registered in different positions and postures that simulate the real working postures and positions in the conventional form. Hence, to achieve better efficiency, human comfort and safety, it is necessary to design the equipment by considering anthropometric data, keeping in view the operator's capabilities and limitations.

II. METHODS

A. Subjects

Sixty two agricultural workers are chosen from four districts of Maharashtra for measurements. Subjects were selected depending on basis of size of population. Total sixty three subjects, in the age group 20-60 years of age were randomly taken. Purpose of study was explained to workers before starting measurement. Personal information like name, address and photo were collected as per standard practice. Consent was taken from each subject prior to collection of data.

B. Body dimensions

Sixty- four body dimensions, including age and body weight were included for the study. There are 31 measurements in standing position, 13 measurements in sitting position and 17 in sitting/standing position. Table-1 shows description of each dimension. Description provides actual landmark which were used for measurements.

Table-1 Anthropometric Parameters Description

Sr. No	Parameters	Description
1	Weight (Kg)	Weight of subject, when subject stand on the center of the weight scale platform
2	Right Hand Grip Strength (Kg)	Grip strength is the force applied by the hand to pull on and is a specific part of hand strength
3	Left Hand Grip Strength (Kg)	
Standing		
4	Stature	Vertical distance from a standing surface to the top of the head
5	Eye Height	The height of the inner corner of the eye
6	Acrominal Height	Vertical distance between the standing surface and the acromion landmark on the tip of the shoulder
7	Axilla Height	Vertical distance between the standing surface and the axillary fold at the anterior scye landmark on torso
8	Chest Height	Vertical distance between the standing surface and the bust point on women and the nipple on men
9	Tenth Rib Height	Vertical distance between the standing surface and the tenth rib landmark at the bottom of the ribcage
10	Iliocristale Height	Vertical distance between the standing surface and the illiocristale landmark on the top of the right side of the pelvis
11	Waist Height, Omphalion	Vertical distance between the standing surface and the center of the navel (omphalion)
12	Olecranon Height	The distance from the tip of the olecranon from the standing Surface
13	Elbow height	The height of the radiale
14	Crotch Height	Vertical distance between the standing surface and the crotch
15	Knee Height, Midpatella	Vertical distance between the standing surface and the center of the knee at the midpatella landmark
16	Wrist-wall Length	Horizontal distance between a wall against which the posterior trunk is in contact and the stylion landmark on the wrist
17	Wrist-wall Length, Extended	Horizontal distance between a wall against which the posterior trunk is in contact and the stylion landmark on the wrist when the arm is maximally extended
18	Acromion-wall Length	Horizontal distance between the acromion landmark on the tip of the shoulder and the back at the same level
19	Acromion – Radiale Length	Distance between the acromion landmark at the tip of the shoulder and radial landmark on the elbow
20	Radiale Stylion Length	Distance between the radiale landmark on the elbow and the stylion landmark on the wrist
21	Shoulder-Elbow Length	Distance between the acromion landmark on the tip of the shoulder and the olecranon landmark at the bottom of the elbow flexed to 90 degrees
22	Forearm Hand Length	Horizontal distance between the back of the tip of the elbow to the tip of the middle finger
23	Forearm Centre of Grip Length (Elbow Grip Length)	Horizontal distance between the back of the tip of the elbow and the hole in the center of the gripped dowel
24	Waist back Length, Omphalion	The dimension on a body, taken from the top of the back bone at the base of the neck to the waistline
25	Interscyle I	Distance across the back between the top of the right and left axillary fold posterior landmarks
26	Chest Breadth	Maximum horizontal breadth of chest at the level of the bust point/thelion
27	Waist Breadth, Omphalion	Horizontal breadth of the waist at the level of the center of the navel (omphalion)
28	Hip Breadth	Horizontal distance between the hips at the level of the lateral buttock landmarks
29	Bispinous Breadth	Distance between the right and left anterior superior iliac spine landmarks
30	Waist Depth, Omphalion	Horizontal distance between the front and back of the waist at the level of the center of the navel (omphalion)

31	Sleeve Length, Outsteam	Straight line distance between the acromion landmark on the tip of the shoulder and the stylion landmark on the wrist
32	Waist Circumference, Omphalion	Horizontal distance around the torso at the level of the center of the navel (omphalion)
33	Buttock Circumference	Horizontal circumference of the trunk at the level of the maximum protrusion of the right buttock
34	Knee Circumference, Standing	Horizontal circumference of the knee at the level of the midpatella landmark (standing).
Sitting		
35	Sitting Height	Vertical distance between the sitting surface and the top of the head.
36	Eye Height,	Vertical distance between the sitting surface and the ectocanthus landmark at the outer corner of the eye.
37	Acrominal Height	The vertical distance between a sitting surface and the acromion landmark on the tip of the right shoulder
38	Elbow Rest Height	The vertical distance from the tip of the olecranon from the sitting Surface
39	Thigh Clearance (Height)	Vertical distance between the sitting surface and the highest point on the top of the thigh
40	Knee Height	Vertical distance between the bottom of the planted foot and the suprapatellar landmark (located standing)
41	Popliteal Height	Vertical distance between the foot surface and the bottom of the thigh just behind the knee
42	Hip Breadth	Lateral maximum hip or tight breadth (whichever is broader) of a seated subject
43	Bideltoid Breadth	Maximum horizontal distance between the lateral margins of the upper arms on the deltoid muscles
44	Biacrimial Breadth	Posterior distance between the right and the left acromion landmarks on the tips of the shoulders
45	Elbow–Elbow Breadth	The distance across the lateral surfaces of the elbows measured with the elbows flexed and resting lightly against the body
46	Buttock Knee Length	Horizontal distance between the most posterior point on either buttock or the front of the knee as measured in the sitting position with the knees flexed 90 degrees
47	Buttock Popliteal Length	Horizontal distance between the most posterior point on the buttock and the back of the knee as measured in the sitting position with the knees flexed 90 degrees
Sitting / Standing		
48	Wrist circumference	A measurement of the wrist at its thinnest point, just proximal to the hand
49	Elbow Circumference, Straight	Circumference of the elbow in a plane perpendicular to the long axis of the arm at the level of the olecranon center landmark, with the arm straight at the side
50	Coronoid Fossa to Hand Length, Sitting	Distance between tip of middle finger to radiale
51	Foot Length	Distance between the tip of the longest toe and the back of the hell of the standing foot
52	Ball of Foot Length(Instep length)	Distance between the back of the heel and the landmark at the first metatarsophalangeal protrusion on the ball of the foot
53	Foot Breadth	Maximum breadth of the standing foot between the first and the fifth metatarsophalangeal landmark protrusions
54	Bimalleolar Breadth	Horizontal distance between the maximum protrusions of the ankle bones (medial and lateral malleoli)
55	Hand Length	Length of the hand between the stylion landmark on the wrist and the tip of the middle finger
56	Wrist-Index Finger Length	Distance between the stylion on the wrist and the tip of the index finger
57	Palm Length	Distance between the stylion on the wrist and root of middle finger
58	Hand Breadth(At Metacarpal-III)	Maximum breadth of the hand between the metacarpal II and the metacarpal V
59	Hand Breadth Across Thumb	Maximum breadth of hand between the metacarpal II and outer edge of thumb
60	Grip Diameter(Inside)	Subject holds a cone around the largest circumference that can be grasped with the thumb and middle finger just touching

61	Grip Diameter (Outside)	Subject holds a cone at the largest circumference that can be grasped with the thumb and middle finger just touching
62	Middle Finger Palm Grip Diameter	Subject holds a stick of various diameters around the largest circumference that can be grasped with the root of middle finger and middle finger just touching. Record the diameter of the cone corresponding to this maximum circumference
63	Grip Span	Subject holds a flat triangular plate at the largest circumference that can be grasped with middle span of hand
64	Age (years)	Age of subject in years

C. Equipments

A standard weighing scale (0- 150 Kg) of least count 100 gm was used for weight measurement. For grip strength measurement of both hands, electronic hand dynamometer of least count 10 gm was used. For sitting, standing body dimensions calibrated anthropometer, segmometer, flexible but non stretchable tape of least count 1mm and adjustable stool were used with leveled platform. For hand and foot measurements, wooden cone, Span measurer, vernier caliper were used. Anthropometers were calibrated periodically before use. Similarly, the weighing scale was calibrated against standard weights of 10–100 kg.

D. Procedure

Two teams containing three members in each team were taken for measurements. All members were trained for identifying landmarks on body and measurements as per standards. One member is for writing down reading and another two are for measurements. Before starting actual measurements, pilot readings of 10 subjects were taken twice. Workers who appeared to be not normal like dwarfs or giants were not taken into consideration as a subject for this study.

III. RESULT AND DISCUSSION

Table-2 provides a descriptive analysis of 63 anthropometric parameters of male agricultural workers from four districts of Western Maharashtra. It presents minimum, maximum, Standard deviation, standard error of mean, coefficient of variance and 5^{th}, 50^{th}, 95^{th} percentile values of each parameter. SEM values for weight, grip strength and weight are above 0.8. SEM values for other body dimensions are generally small. From table, it is observed that CV% of some body dimensions like elbow–elbow breadth, waist circumference (omphalion), acromion-wall length, middle finger palm grip diameter, grip span, age, elbow rest height, thigh clearance, radiale stylion length, waist back length and waist breadth are high.

Table -2 Anthropometric Data Analysis Sheet

Sr. No.	Dimension	Min	Max	Mean	SD	SEM	CV (%)	Percentile values		
								5th	50th	95th
1	Weight (Kg)	41.2	84.3	61.08	7.94	0.94	13	48.2	61.3	73.5
2	Right Hand Grip Strength (Kg)	11.9	41.1	28.01	6.75	0.8	24.1	18.7	27.3	39.4
3	Left Hand Grip Strength (Kg)	10	51	27.9	7.75	0.91	27.78	16.4	27.4	39.5
4	Stature	150	174.7	164.43	5.61	0.66	3.41	156.5	165	172.5
5	Eye Height, Standing	139	165.6	154.53	5.7	0.67	3.69	147	155.5	162.5
6	Acrominal Height, Standing	124.4	147	137.2	5.06	0.6	3.69	129.2	137.2	144.7
7	Axilla Height	112.2	135	124.6	5.11	0.6	4.1	116.3	125.5	131.1
8	Chest Height	109.2	130.7	122.06	4.89	0.58	4.01	115	122.2	129
9	Tenth Rib Height	90.7	114.2	106.7	4.83	0.57	4.53	99.7	106.5	113.5
10	Iliocristale Height	83.9	105.5	97.13	4.79	0.56	4.93	90	97.8	102.8
11	Waist Height, Omphalion	84.2	110	99.56	5.03	0.59	5.05	90	100.7	106.8
12	Olecranon Height, Standing	88.2	111	102.39	4.92	0.58	4.81	94.5	103.2	108.8
4	Elbow height, Standing	93.7	113.8	104.3	4.41	0.52	4.23	95.5	104.3	111.1
14	Crotch Height	62.6	94.5	75.96	5.97	0.7	7.86	65	76.4	83.5

15	Knee Height, Midpatella	40.2	53.2	48.14	2.79	0.33	5.8	43	48.3	52
16	Sitting Height	74.9	91.4	84.45	3.07	0.36	3.64	79.9	84.8	88.2
17	Eye Height, Sitting	65.9	85.7	75.23	3.26	0.38	4.33	69.4	75	79
18	Acromial Height, Sitting	46.2	62.4	56.97	3.28	0.39	5.76	52.4	57	62
19	Elbow Rest Height, Sitting	16.8	28	22.63	2.47	0.29	10.91	18.4	22.6	26.6
20	Thigh Clearance (Height)	10.2	15.9	13.06	1.34	0.16	10.26	11	13.1	15.4
21	Knee Height, Sitting	43	54	49.18	2.36	0.28	4.8	45	49.5	52.1
22	Popliteal Height, Sitting	38.4	49.6	43.39	1.98	0.23	4.56	40.6	43.1	46.5
23	Wrist-wall Length	58	71	64.13	3	0.35	4.68	59.5	64	68
24	Wrist-wall Length, Extended	61.2	74.2	66.91	2.89	0.34	4.32	62.5	67	71
25	Acromion – Radiale Length	25	39.5	32.57	2.4	0.28	7.37	29	32	36
26	Radiale Stylion Length	22.2	37.5	26.81	2.5	0.29	9.32	24	27	31
27	Shoulder-Elbow Length	26	43	37.32	2.96	0.35	7.93	33.5	37.2	41
28	Forearm Hand Length	40.5	51	45.7	2.02	0.24	4.42	42	46	49
29	Forearm Centre of Grip Length (Elbow Grip Length)	29.5	47.5	34.31	3.23	0.38	9.41	31.4	34	38.5
30	Waist back Length, Omphalion	33	52	41.15	3.33	0.39	8.09	36	41.5	45.5
31	Interscyle I	24.5	39	31.64	3.18	0.37	10.05	27	32	36
32	Chest Breadth	24.4	33.8	26.89	1.98	0.23	7.36	24.4	26.5	30.525
33	Waist Breadth, Omphalion	18.7	33.2	26.06	2.59	0.31	9.94	21.55	26.5	29.81
34	Hip Breadth, Standing	23.5	35.3	30.18	2.31	0.27	7.65	26.685	30.15	34
35	Bispinous Breadth, Standing	22	30.8	25.78	2.15	0.25	8.34	22.195	25.5	29.01
36	Hip Breadth, Sitting	28.3	38.5	32.11	2.13	0.25	6.63	29.385	32	35.025
37	Bideltoid Breadth	35.6	45.9	40.43	2.19	0.26	5.42	36.97	40.5	44.065
38	Biacrimial Breadth	23.7	39	32.93	2.27	0.27	6.89	30.69	32.35	36.05
39	Elbow–Elbow Breadth-Sitting	32.7	52.7	40.23	3.82	0.45	9.5	33.695	40.55	45.575
40	Waist Depth, Omphalion	11	37	20.07	4.15	0.49	20.68	15.17	20	25.09
41	Sleeve Length, Outseam	53	69	60.15	2.99	0.35	4.97	55.285	60	65
42	Wrist circumference	14.5	19	15.76	0.81	0.1	5.14	14.695	15.5	17.005
43	Elbow Circumference, Straight	18.5	28	23.54	1.69	0.2	7.18	20.095	24	26
44	Knee Circumference, Standing	22.2	40	33.53	2.9	0.34	8.65	29.19	33.9	37.525
45	Waist Circumference, Omphalion	63.2	108	82.38	8.82	1.04	10.71	67.425	83	94.17
46	Buttock Circumference	73.4	109	88.52	6.15	0.72	6.95	79.435	89.7	96.34
47	Acromion-wall Length	8.2	12.5	10.4	1.13	0.13	10.87	8.595	10.4	12.31
48	Buttock Knee Length, Sitting	50.5	66.2	58.14	3.01	0.35	5.18	53.475	58	62.25
49	Buttock Popliteal Length, Sitting	42	53.7	48.91	2.67	0.31	5.46	44.395	49.1	52.525
50	Coronoid Fossa to Hand Length, Sitting	34	43.5	39.87	2.23	0.26	5.59	35.975	40	43.12
51	Foot Length	21.5	26.7	24.54	1.06	0.12	4.32	23.1	24.5	26.1
52	Ball of Foot Length(Instep length)	8.7	28.5	18.36	2.39	0.28	13.02	16.6	18.1	20.5
53	Foot Breadth	7.4	18.8	9.19	1.42	0.17	15.45	8	9	10.2
54	Bimalleolar Breadth	5.6	8.4	6.72	0.48	0.06	7.14	6	6.6	7.5

55	Hand Length	16.3	25.6	18.19	1.22	0.14	6.71	16.5	18.1	19.3
56	Wrist-Index Finger Length	14.7	18.7	16.76	0.84	0.1	5.01	15.2	16.8	18
57	Palm Length	9.1	11.9	10.35	0.6	0.07	5.8	9.4	10.3	11.4
58	Hand Breadth(At Metacarpal-III)	6.2	8.9	8.06	0.48	0.06	5.96	7.5	8.2	8.6
59	Hand Breadth Across Thumb (Standing/sitting)	8.7	10.9	9.83	0.55	0.06	5.6	9	9.9	10.7
60	Grip Diameter(Inside) (Standing/sitting)	3.9	5.7	4.81	0.41	0.05	8.52	4.1	4.8	5.4
61	Grip Diameter (Outside) (Standing/sitting)	6.7	9.7	8.23	0.53	0.06	6.44	7.2	8.3	9
62	Middle Finger Palm Grip Diameter (Standing/sitting)	2	3.6	3.08	0.29	0.03	9.42	2.6	3.1	3.5
63	Grip Span (Standing/sitting)	7.5	11	8.76	0.82	0.1	9.36	7.5	8.5	10.5
64	Age (years)	20	60	45.23	11.1	1.31	24.54	27	47	60

Measurements are in cm unless otherwise explicitly mentioned.
Min. = minimum, Max. = maximum, SD. = standard deviation, SEM = standard error of mean, CV = coefficient of variation

IV. CONCLUSION

It is generally observed that, there is great difference in dimensions of tools, machine, workstations and equipments with worker's body dimensions. Discomfort produced due to products or workstation which is not ergonomically designed causes dangerous disorder in various parts of body. In ergonomic evaluation of agricultural equipments, Industrial workstations and office workstations, anthropometric data of particular community is must. Software based human posture analysis also require anthropometric data to create digital manikin.

REFERENCES

[1] K. Goel, D. Behera, B. K. Behera, S. K. Mohanty and S. K. Nanda, "Development and Ergonomic Evaluation of Manually Operated Weeder for Dry Land Crops", Agricultural Engineering International, 9(5), pp. 1-8, 2008.

[2] Adarsh Kumara, Dinesh Mohanb, Rajesh Patel and Mathew Varghese, "Development of grain threshers based on ergonomic design criteria", Applied Ergonomics, 33, pp. 503–508, 2002.

[3] Anjen Chao, Anil I. Kumar, Kumar Nagarajrao and Heecheon You, "An Ergonomic evaluation of Cleco Pliers", HFES 2000 Congress, pp. 441-442, 2000.

[4] Arunesh Chandra, Pankaj Chandana and Surinder Deswal, "Analysis of hand anthropometric dimensions of male industrial workers of Haryana state", International Journal of Engineering (IJE), 5(3), pp.242-256, 2011.

[5] R. Mehta, P. S. Tiwari, S. Rokade, M. M. Pandey, S. C. Pharade, L. P. Gite and S. B. Yadav, "Leg strength of Indian operators in the operations of tractor pedals", International Journal of Industrial Ergonomics, 37(4), pp. 303-311, 2007.

[6] Chin-Chiuan Lin, "Ergonomic Assessment of Excavator Seat", International Journal of Applied Science and Engineering 9(2), pp. 99-109, 2011.

[7] T. Khogare and Sunita Borkar, "Anthropometric data of agricultural workers for suggesting dimensions of manually operated weeder", Asian journal of home science, 6(1), pp. 57-60, 2011.

[8] H. Hasio, J. Whitestone, B. Bradtmiller, R. Whisler, J. Zwiener, C. lafferty, T.Y. Kau and M. Gross, "Anthropometric criteria for the design of tractor cabs and protection frames", Ergonomics, 48(4), pp. 323-353, 2005.

[9] J. Sanjog, S. Karmakar, H. Agarwal, C. Dattu and K. Patil, "Designing and Ergonomic Evaluation of a Shoe-Rack in CAD Environment", International Journal of Computer Applications, 49(20), pp. 0975 – 0982, 2012.

[10] K. N. Agrawal, R. K. Singh and K. K. Satapathy, "Anthropometric considerations for farm tools/machinery design for tribal workers of North Eastern India", Agricultural Engineering International: the CIGR Ejournal, Manuscript MES 1406 Vol. XII, 2010.

[11] K. N. Dewangan, C. Owary, R. K. Datta, "Anthropometric data of female farm workers from north eastern India and design of hand tools of the hilly region", International Journal of Industrial Ergonomics, 38, pp. 90–100, 2008.

[12] Mahendra Singh Khidiya and Awadhesh Bhardwaj, "Design, development and ergonomics evaluation of a hand operated spade (phawra)", HFESA Journal, Ergonomics Australia Vol 24, pp. 200-209, 2010.

[13] P. Baral, S. W. Lobo, R. G. Menezes, T. Kanchan and K. Krishan, S. Bhattacharya, S. S. Hiremath, "An anthropometric study of facial height among four endogamous communities in the Sunsari district of Nepal", Singapore Med J, 51(3), pp. 212, 2010.

[14] P. K. Nag, Agricultural Ergonomics, pp. 263–264, 1992.

[15] Prabir Mukhopadhyay and Saurabh Srivastava, "Ergonomics risk factors in some craft sectors of Jaipur", HFESA Journal, Ergonomics Australia Vol 24, 1991.

[16] Rajvir Yadav and Sahastrarashmi Pund, "Development and Ergonomic Evaluation of Manual Weeder", Agricultural Engineering International: CIGR Ejournal. Manuscript PM 07 022. Vol. IX, 2007.

[17] Rajvir Yadav, Sahastrarashmi Pund, N. C. Patel and L. P. Gite, "Analytical study of strength parameters of Indian farm workers and its Implication in equipment design", Agricultural Engineering International Journal, 9, pp. 1-8, 2010.

[18] S. Kumar, "Arm lifts strength in workplace", Applied Ergonomics, 22 (5), pp. 317-328, 1991.

[19] Victor Paquet and David Feathers, "An anthropometric study of manual and powered wheelchair users", International Journal of Industrial Ergonomics 33, pp. 191–204, 2004.