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Comparative Analysis of Various Anthropometric Dimensions for Male Agricultural Farm Workers in different Regions of India

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Abstract: ***Various studies reported that agricultural sector is very hazardous in case of injuries and musculoskeletal disorders. A very large workforce is engaged in this sector hence the researchers should be focused in this sector for the improved machinery and equipment designs. A better compatibility of the worker with equipment enhances the safety and performance of the user. In this comparative study of various anthropometric traits of different regions of Indian agricultural population it is observed that north Indian males are largest (stature) out all regional population (1665 mm). Hand length found highest for central Indian workers (185 mm) and hand breadth is found highest for north Indian workers (100 mm).***
Key words: musculoskeletal disorders, Anthropometry, ergonomics, agricultural injuries

I. INTRODUCTION

In the daily tasks farm workers use a number of machine tools, manual tools and equipments. These tools must be compatible as per the physical traits of the user. Mismatches of tool dimension and user physical characteristics are the main concerned factors in reducing the worker's efficiency and can cause injuries and musculoskeletal disorders (MSDs) [Mandahawi et al., 2008]. So a number of researchers have reported the significance of relevancy of anthropometric data in tool and equipment design [Graves, 1992; Kar et al. 2003; Okunribido, 2000]. Anthropometric traits noticeably varies across gender, age, race, geographical locations, nutritional nature and types of work [Oduma et al., 2017]. It is reported and observed the presently agricultural mechanization needs a good knowledge of ergonomics for the better agricultural tools design with the specific concern of safety, comfort and efficiency of user using them [Yadav et al., 2000]. Different hand tools require different force and handling i.e some needs small force and some needs large handle forces so there is much complexity in ergonomic design of agricultural hand tools which require hand anthropometry [kar et al., 2003]. In general, hand tools are enormously heavy and tend to slip, hence difficult to handle and reduces efficiency of the user. Some users also try to personalize the tool design for their personal comfortability i.e. by reducing the diameter or varying the length of handle, removing protrusions or some sharp edges [Adegbite, 1994]. Till today, many manual tools are used in agricultural tasks in India i.e. from seedbed preparation to post harvest activities. Western nations have created the databases for anthropometric design references [Thompson, 1972; NASA, 1978; Syed, 1993]. Yet, such databases for Indian agricultural population is not available [Yadav et al., 2010; Vyavahare et al., 2016]. Various researchers from their studies and surveys has been reported that agricultural activities are highly prone to injuries and musculoskeletal disorders [Kharb et al., 2015]. Anthropometry plays a significant role in equipment design. Hence a critical study is done to compare the different anthropometric parameters of agricultural male population for different regions in India. In this present study, aim is to know the difference of mean of various anthropometric parameters so that the concept of tools design on the basis of anthropometry and its relevancy could be understood.

II. MATERIALS AND METHOD

A. Sampling for the survey

For the measurement (sample) workers selected were selected randomly and observed keenly to know that they must be free from any injury and musculoskeletal disorders. After knowing their health they were told the aim of research and measurement then after their consent they were considered as subject. All the selected subjects lie in the range of 18-60 years age group.

B. Apparatus used

The following equipments were used for data collection

1) Anthropometer: to measure the various standing and sitting posture dimensions.
2) Wooden Cone: to measure the different grip diameters
3) Weighing scale: 100gm sensitivity, used to measure the body weight
4) Non-stretchable measuring tape: to measure wrist circumference
5) Vernier calliper: to measure different hand dimensions

C. Measurement Procedure

A team of well trained members went to the place of survey and took the sarpanch (head) of the village in confidence. Sarpanch of each surveyed village were informed about the aim of whole research then only with the help of sarpanch the workers were informed and called to come for subject selection *[Dewangan et al, 2010]*. During measurement subjects were asked to stand in the erect position with stretch shoulder in such a way that heel, buttock and head should touch the vertical plane *[NASA, 1978]*. Different breadth and height concern dimensions were measured using anthropopmeter. Vernier caliper was used to measure the different hand dimensions i.e. palm width, hand length, hand breadth etc. Measuring tape was used measure the girth of wrist. The whole procedure of measurement was repeated for three times to minimise the error in data collection.

D. Data Analysis

Mean and standard deviation was calculated from the collected data and presented in table1. Data of various regions of India is shown in table 1 i.e. North India(NI), North East India (NEI), East India (EI), Central India (CI), West India (WI) and South India (SI). 5th percentile and 95th percentile was calculated from the following formula:

$X = \mu + (z * \sigma)$ *[Yadav R., 1995]*

Where X is the ith percentile

μ = mean of the data

z = -1.645 for 5th percentile and +1.645 for 95th percentile

σ = standard deviation of the collected data for the specific region.

Calculated 5th and 95th percentile for the each specific region is shown in the table 2 and table 3 respectively. Calculated percentiles are used to design various farm tools and machinery anthropometrically *[Dixit et al., 2000]*.

III. RESULTS AND DISCUSSION

A. Results

Mean and standard deviation was analysed and compared for the different regions of India. Complete descriptive information is shown in table 1, 2 and 3. Machinery or farm manual tools are mainly designed for the 90 percentile i.e. (between 5th and 95th percentile). Hence mean, SD percentile are calculated and analysed to know the permissible limits of workers of the specific region. The height is highest for north Indian males found to be 1665 mm, smallest males are measured from north east Indian males i.e. 1618 mm.

B. Discussion

From table 1 it is observed that the highest stature is found for north Indian males and north Indian males are smallest out of all regions. North Indian males are larger by 2.9% than north east Indian males. Highest grip diameter (inside) for central Indian males (51 mm) is greater by 11.7% than lowest inside grip diameter (45 mm) Which is for north east Indian males.

Largest sitting height (845 mm) is found for eastern Indian males and smallest for south Indian males (781 mm), which is greater by 7.5%. Hand length for central Indian males is greater than north east Indian males by 5.9%. Highest hand breadth across thumb is observed for north Indian males (100 mm) and smallest is for east Indian males (95 mm), which is found smaller by 5% than north Indian males. From these results it can be suggested very well that from the above results some significant differences are observed in grip diameter which is critical dimension for fixing the handle diameters for the different agricultural tools. A significant difference is observed for hand breadth across thumb. Hand breadth is important parameter to decide the handle length for various hand tools like sickle.

Table1 Mean(SD) of different anthropometric dimensions of male agricultural farm workers for various regions in India

Sl no.	Dimension	NI	NEI	EI	WI	CI	SI
1	Weight	61 (8)	55 (6)	51.6 (7.6)	54.1 (8.4)	50.8 (6.6)	56.1 (9.7)
2	Stature	1665 (68)	1618 (62)	1631 (66)	1628 (68)	1640 (65)	1629 (65)
3	Eye height	1556 (68)	1500 (63)	1517 (65)	1523 (65)	1540 (68)	1510 (67)
4	Acromial height	1391 (68)	1337 (58)	1351 (59)	1367 (60)	1367 (62)	1372 (62)
5	Elbow height	1051 (59)	1007 (47)	1023 (48)	1029 (54)	1040 (48)	1018 (49)
6	Trochanteric height	814 (48)	758 (49)	783 (50)	829 (53)	855 (46)	869 (51)
7	Metacarpal III height	708 (55)	686 (42)	683 (40)	683 (43)	698 (38)	684 (41)
8	Knee height	488 (41)	456 (31)	466 (30)	479 (29)	468 (25)	478 (30)
9	Biacromial breadth	356 (33)	360 (24)	313 (31)	317 (30)	315 (26)	309 (26)
10	Bideltoid breadth	429 (29)	415 (26)	392 (26)	424 (30)	413 (23)	414 (32)
11	Wrist Circumference	165 (9)	161 (10)	156 (9)	156 (10)	158 (8)	163 (10)
12	Grip diameter (inside)	50 (5)	45 (4)	46 (6)	50 (4)	51 (5)	49 (4)
13	Grip diameter (outside)	91 (8)	81 (6)	84 (7)	94 (7)	98 (8)	83 (6)
14	Middle finger palm grip diameter	31 (6)	20 (2)	29 (4)	29 (4)	30 (4)	28 (2)
15	Sitting height	842 (56)	841 (40)	845 (41)	816 (44)	810 (36)	781 (83)
16	Sitting eye height	744 (56)	729 (41)	736 44)	719 (42)	743 (36)	670 (79)
17	Sitting acromial height	577 (56)	571 (37)	575 (36)	556 (37)	572 (31)	561 (79)
18	Elbow rest height	227 (36)	228 (30)	216 (30)	200 (26)	214 (23)	201 (25)
19	Knee height sitting	526 (42)	494 (29)	481 (27)	506 (31)	503 (28)	507 (26)
20	Popliteal height sitting	423 (39)	400 (28)	415 (23)	430 (27)	415 (25)	422 (24)
21	Elbow grip length	357 (34)	349 (23)	347 (27)	357 (29)	347 (19)	361 (26)
22	Hand length	180 (13)	174 (10)	178 (10)	178 (10)	185 (10)	181 (10)
23	Palm length	101 (8)	99 (6)	102 (7)	98 (8)	106 (7)	102 (7)
24	Hand breadth across thumb	100 (7)	97 (6)	95 (8)	97 (7)	99 (6)	99 (8)
25	Hand breadth	83 (6)	77 (6)	77 (7)	81 (5)	83 (5)	81 (5)
26	Elbow elbow breadth sitting	398 (39)	401 (27)	360 (43)	366 (39)	372 (29)	356 (45)

[Gite et al., 2009]

Table2 5th percentile of different anthropometric dimensions of male agricultural farm workers for various regions in India

Sl no.	Dimension	NI	NEI	EI	WI	CI	SI
1	Weight	47.84	45.13	39.098	40.282	39.943	40.1435
2	Stature	1553.14	1516.01	1522.43	1516.14	1533.075	1522.075
3	Eye height	1444.14	1396.365	1410.075	1416.075	1428.14	1399.785
4	Acromial height	1279.14	1241.59	1253.945	1268.3	1265.01	1270.01
5	Elbow height	953.945	929.685	944.04	940.17	961.04	937.395
6	Trochanteric height	735.04	677.395	700.75	741.815	779.33	785.105
7	Metacarpal III height	617.525	616.91	617.2	612.265	635.49	616.555
8	Knee height	420.555	405.005	416.65	431.295	426.875	428.65
9	Biacromial breadth	301.715	320.52	262.005	267.65	272.23	266.23
10	Bideltoid breadth	381.295	372.23	349.23	374.15	375.165	361.36
11	Wrist Circumference	150.195	144.55	141.195	139.55	144.84	146.55
12	Grip diameter (inside)	41.775	38.42	36.13	43.42	42.775	42.42
13	Grip diameter (outside)	77.84	71.13	72.485	82.485	84.84	73.13
14	Middle finger palm grip diameter	21.13	16.71	22.42	22.42	23.42	24.71

15	Sitting height	749.88	775.2	777.555	743.62	750.78	644.465
16	Sitting eye height	651.88	661.555	663.62	649.91	683.78	540.045
17	Sitting acromial height	484.88	510.135	515.78	495.135	521.005	431.045
18	Elbow rest height	167.78	178.65	166.65	157.23	176.165	159.875
19	Knee height sitting	456.91	446.295	436.585	455.005	456.94	464.23
20	Popliteal height sitting	358.845	353.94	377.165	385.585	373.875	382.52
21	Elbow grip length	301.07	311.165	302.585	309.295	315.745	318.23
22	Hand length	158.615	157.55	161.55	161.55	168.55	164.55
23	Palm length	87.84	89.13	90.485	84.84	94.485	90.485
24	Hand breadth across thumb	88.485	87.13	81.84	85.485	89.13	85.84
25	Hand breadth	73.13	67.13	65.485	72.775	74.775	72.775
26	Elbow elbow breadth sitting	333.845	356.585	289.265	301.845	324.295	281.975

Table3 95th percentile of different anthropometric dimensions of male agricultural farm workers for various regions in India

Sl no.	Dimension	NI	NEI	EI	WI	CI	SI
1	Weight	74.16	64.87	64.102	67.918	61.657	72.0565
2	Stature	1776.86	1719.99	1739.57	1739.86	1746.925	1735.925
3	Eye height	1667.86	1603.635	1623.925	1629.925	1651.86	1620.215
4	Acromial height	1502.86	1432.41	1448.055	1465.7	1468.99	1473.99
5	Elbow height	1148.055	1084.315	1101.96	1117.83	1118.96	1098.605

6	Trochanteric height	892.96	838.605	865.25	916.185	930.67	952.895
7	Metacarpal III height	798.475	755.09	748.8	753.735	760.51	751.445
8	Knee height	555.445	506.995	515.35	526.705	509.125	527.35
9	Biacromial breadth	410.285	399.48	363.995	366.35	357.77	351.77
10	Bideltoid breadth	476.705	457.77	434.77	472.85	450.835	466.64
11	Wrist Circumference	179.805	177.45	170.805	172.45	171.16	179.45
12	Grip diameter (inside)	58.225	51.58	55.87	56.58	59.225	55.58
13	Grip diameter (outside)	104.16	90.87	95.515	105.515	111.16	92.87
14	Middle finger palm grip diameter	40.87	23.29	35.58	35.58	36.58	31.29
15	Sitting height	934.12	906.8	912.445	888.38	869.22	917.535
16	Sitting eye height	836.12	796.445	808.38	788.09	802.22	799.955
17	Sitting acromial height	669.12	631.865	634.22	616.865	622.995	690.955
18	Elbow rest height	286.22	277.35	265.35	242.77	251.835	242.125
19	Knee height sitting	595.09	541.705	525.415	556.995	549.06	549.77
20	Popliteal height sitting	487.155	446.06	452.835	474.415	456.125	461.48
21	Elbow grip length	412.93	386.835	391.415	404.705	378.255	403.77
22	Hand length	201.385	190.45	194.45	194.45	201.45	197.45
23	Palm length	114.16	108.87	113.515	111.16	117.515	113.515
24	Hand breadth across thumb	111.515	106.87	108.16	108.515	108.87	112.16
25	Hand breadth	92.87	86.87	88.515	89.225	91.225	89.225
26	Elbow elbow breadth sitting	462.155	445.415	430.735	430.155	419.705	430.025

IV. CONCLUSION

Different body dimensions are compared for various regions in India of male agricultural workers. North Indian males are largest in the other region population of Indian agricultural workers. Hand length of central Indian meals is found highest. Grip diameter is highest for the Central Indian males hence the diameter of handle of various hand tools i.e. khurpi, spade, sickle etc. will be the largest for these males. Highest hand breadth is found for north Indian males hence the larger handle length will be suitable for this population.

V. RECOMMENDATION

The use of ergonomics approach ie in design of different farm tool is not much in practice till these days. Hence the anthropometrical approach in tool design must be enhanced to improve the efficiency of farm workers and their safety (reduction of injuries and musculoskeletal disorders).

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