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An Investigation of Hand Anthropometry of Agricultural Workers

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INTRODUCTION

India is an agriculture-based country. A large section of Indian population is involved in agriculture. In eastern part of India major agriculture in paddy cultivation. For example in West Bengal state a large section of labours (men 22.65% and women 37.88%) are associated with paddy cultivation jobs (Census of India, 1991). They use different type of hand tools for various steps of paddy cultivation. Hand tools need to fit the contours of hand; they need to be held securely with suitable wrist and arm posture, they may be utilizing strength and energy capabilites without over loading the body. For effective use of tools and implements that require workers to maintain a power grip during task performance, adequate space must be provided on the handle (Okunribido, 2000). Some hand tools require a fairly small force but precise handling and other hand large force but increase handling. Hence, the design of agricultural hand tools is a complex ergonomic taks and requires hand anthropometry.

Over the centuries, human have used tools to accomplish a variety of objectives, typically related to agricultural jobs. Today, there is a growing demand among professional hand tool users to have ergonomically designed products (Schmidtke, 1984; Snow, 1984). Many people need them, but a few know anything about them. If better fitted hand tools or appliance are to be produced for agricultural workers, knowledge of the hand dimensions is required. This information is also useful of determining various aspeccts of industrial machinery (Imrhan et al., 1993, Lewis and Narayan, 1993). An anthropometric study of Hong Kong Chineser female hands was carried out using 100 subjects. The 24 hand measurements that were taken those thought to be special importance for the design of machinery and machine guards (Courtsey, 1984).

To design any product for human use, engineers have to rely on anthropometric data, otherwise the resulting product may turn out to be ergonomically incompatible (Lewis, 1969; Haslegrave, 1986). The depth and breadth of each segment of the hand were measured at points that were spaced at approximately equal distance between the joints of the hand (Buchholz and Armstrong, 1991). An et al. (1979) have published data on the mean length of the proximal and middle phalangeal segments for the four fingers, but do not relate these data to the wrist joint nor do they locate the metacarpophalangeal joints with respect to each other. The interaction of handle size and shape with the kinematics and anthropometry of the hand have a great effect on hand posture and grip strength (Buchholz et al., 1992). Recently an anthropometric survey measuring 18 dimensions of the right hand in 37 female rural farm owrkers living in Ibandan, Western Nigeria was conducted (Okunribido, 2000). The means of the collected data are compared with those for female from the UK, Hong Kong and America.

In Indian agriculture, hand tools, animal-drawn equipment and tractor/power operated machinery are extensively used for various operations. This equipment are either operated or and controlled by human workers (Gite Yadav, 1989). Use of anthropometric data can help in the proper design of equipemnt for better efficiency and more human comfort. Available anthropo-metric data or Indian farm workers were compiled (Gite Yadav, 1989; Yadav et al., 1997) which could be and useful in farm machinery design and inclusion of other dimensions was suggested for making the data more comprehensive. Sen et al. (1977) and Gupta et al. (1983) pointed out that there was considerable difference between the anthropometric data of Indian and Westerners. Therefore, it is necessary to have data of Indian agricultural workers, both men and women to assist in proper equipment design.

In the present study different hand dimensions of right and left hand of agricultural workers have been collected from Eastern India. The collected anthropometric data were compared with the data of other part of India and abroad.

MATERIALS AND METHOD

Subjects : Measurements were taken from 404 agricultural workers in which 204 female workers having the age range of 18-65 years and 200 male workers having the age range of 18-75 years were included. The subjects covered under the random survey were the labourers working in different agricultural field of Midnapore District, West Bengal State, Eastern India.

Definition of Measurements: Definitions and technique of measurements correspond to the guidelines in NASA 1024 (1978). Eight hand diemnsions have been identified which were considered useful for agricultural hand tools design. The anthropometric deifinition used in this study are summarized below:

1. *Hand Length:* The straight distance between root of the palm and tip of the middle finger.
2. *Palm Length:* The straight distance between root of the palm and root of the middle finger.
3. *Hand Breadth:* The breadth of the palm measured at the level of maximum buldge of the palm excluding thumb.
4. *Maximum Hand Breadth:* The breadth of the hand measured at the level of maximum buldge of the palm including thumb.
5. *Hand Thickness:* The thickness of the hand measure at the level of middle portion of the palm transversely.
6. *Hand Circumference:* The close measurement that follow a hand contour at the maximum palm level, the measurement is not circular.
7. *Maximum Hand Circumference:* The closed measurement that follows a hand contour at the maximum feast level, the measurement is not circular.
8. *Grip Diameter:*Maximum inner curvature of the hand at the touching level between tip of the middle finger and thumb.

Apparatus: A sliding caliper and a steel measuring tapes were used for most of the measurements. Internal grip diameter was measured using a wooden cone specially made for the purpose.

Procedure: Measurements were made on both male and female agricultural workers. The right and left hands of the subjects were included. The measurements were taken under standardized condition and using proper landmarks (Ermakova et al., 1985) the simplest possible methods consistant with the required accuracy were used. These dimensions such as breadth, length and thickness were measured with a sliding caliper where as circumference was measured with a steel tape and for measuring grip diameter a wooden cone was used. Accuracy and repeatability of measurement was achieved by practice prior to the data collection sessions.

Statistical Analysis: Descriptive statistics were summarized in terms of mean, standard deviation (SD) and percentile values. The 't' values and percentage difference were calculated also. Statistical parameters were computed by using computerized statistical analysis software (SPSS).

RESULTS AND DISCUSSION

The anthropometric data of eight hand dimensions of 200 male and 204 female agricultural workers have been shown in table 1. The 't' values was computed (not shown in table) and it was noted that there was a significant difference ($P<0.001$) in body dimensions between right and left hand in both sexes. However their percentage of difference was very small and it ranged from 0.1% to 1.88% in men and 0.19% to 3.49% in women. When the hand dimension were computed between male and female subjects it was observed that the difference in dimensions were statistically significant ($P<0.001$); the percentage of difference in hand dimensions (right and left) ranged from 7.1% to 11.96%).

The percentile values of different hand measurements (right and left) of male and female workers have been presented in table 2. The computed values 5th, 50th, 95th percentiles may be used for designing of hand tools, handles and control pannel in different work field. The data of male and female subjects may be used for designing hand tools seprately for them. However, it is the common practice, among the Indian agricultural workers, to used the same hand tools by the male and female workers. Further, considering the socio-economic condition and common habitual practice of the Indian farmers, the design of hand tools having the same dimensions for both men and women may be adopted. For designing such a hand tool the hand measurements of male and female subjects should be taken as the same

Table 1: Mean ±SD and percentage difference of different hand dimensions (Right and Left) of agricultural workers (Male and Female) in cm.

Dimensions	*Male (n=200)*			*Female (n=204)*			*% difference between Male & Female*	
	Right hand	*Left hand*	*% difference*	*Right hand*	*Left hand*	*% diffrence*	*Right hand*	*Left hand*
Hand Length	17.51 ± 0.85	17.59 ± 0.88	0.45	16.09 ± 0.70	16.06 ± 0.75	0.19	8.11	8.7
Palm length	9.72 ± 0.64	9.73 ± 0.68	0.10	8.85 ± 0.57	8.82 ± 0.55	0.34	8.95	9.35
Hand breadth	8.23 ± 0.44	8.03 ± 0.41	2.43	7.30 ± 0.35	7.07 ± 0.35	3.15	11.3	11.96
Maximum Hand breadth	9.82 ± 0.58	9.68 ± 0.58	1.43	8.75 ± 0.42	8.64 ± 0.48	1.26	10.9	10.74
Hand thickness	2.81 ± 0.28	2.79 ± 0.29	0.71	2.58 ± 0.18	2..49 ± 0.18	3.49	8.19	10.75
Hand circumference	19.44 ± 0.95	19.12 ± 1.16	1.65	17.80 ± 0.95	17.32 ± 0.88	2.70	8.44	9.41
Maximum hand circumference	26.35 ± 1.33	26.00 ± 1.37	1.33	24.48 ± 1.16	23.88 ± 1.36	2.45	7.10	8.15
Grip diameter (inside)	5.23 ± 0.36	5.33 ± 0.37	1.88	4.80 ± 0.29	4.85 ± 0.29	1.03	8.22	9.01

Table 2: Percentile values of different hand dimensions (Right and Left) of Male (n=200) and Female (n=204) agricultural workers, in cm (RH: Right Hnad, LH: Left Hand)

Dimensions	*5th*				*50th*				*95th*			
	Male		*Female*		*Male*		*Female*		*Male*		*Female*	
	RH	*LH*	*RH*	*LH*	*RH*	*LH*	*RH*	*LH*	*RH*	*LH*	*RH*	*LH*
Hand length	16.1	16.1	14.9	14.8	17.5	17.6	16.1	16.1	18.9	19.0	17.2	17.3
Palm length	8.7	8.6	7.9	7.9	9.7	9.7	8.9	8.8	10.8	10.9	9.8	9.7
Hand breadth	7.5	7.4	6.7	6.5	8.2	8.0	7.3	7.1	9.0	8.7	7.9	7.6
Maximum hand breadth	9.0	8.9	8.1	7.9	9.8	9.7	8.8	8.6	10.7	10.5	9.4	9.4
Hand thickness	2.5	2.5	2.3	2.2	2.8	2.8	2.6	2.5	3.2	3.1	2.9	2.8
Hand circum-ference	17.9	17.2	16.2	158.9	19.4	19.1	17.8	17.3	21.0	21.0	19.4	18.8
Maximum hand circumference	24.2	23.7	22.6	21.8	26.4	26.0	24.5	23.9	28.5	28.3	26.4	26.0
Grip diameter (inside)	4.6	4.7	4.3	4.4	5.2	5.3	4.8	4.9	5.8	5.9	5.3	5.3

Table 3: Mean ±SD, percentage difference and percentile values of different hand diemensions (Right and Left) of all agricultural workers including both male and female groups (n=400) in cm.

Dimensions	*Right Hand*	*Left Hand*	*% difference*	*5th*		*50th*		*95th*	
				RH	*LH*	*RH*	*LH*	*RH*	*LH*
Hand length	16.80 ± 1.05	16.83 ± 1.12	0.18	15.07	14.99	16.80	16.83	18.52	18.67
Palm length	9.29 ± 0.75	9.27 ± 0.77	0.22	8.06	8.01	9.29	9.27	10.52	10.54
Hand Breadth	7.77 ± 0.61	7.55 ± 0.61	2.83	6.76	6.55	7.77	7.55	8.77	8.56
Maximum hand breadth	9.29 ± 0.72	9.16 ± 0.72	1.40	8.11	8.00	9.29	9.16	10.47	10.32
Hnad thickness	2.70 ± 0.22	2.64 ± 0.24	2.22	2.33	2.25	2.70	2.64	3.06	3.03
Hand circumfer-ence	18.63 ± 1.24	18.22 ± 1.36	2.20	16.59	15.98	18.63	18.22	20.67	20.45
Maximum hand circumference	25.42 ± 1.56	24.95 ± 1.71	1.85	22.86	22.15	25.42	24.95	27.98	27.75
Grip diameter (inside)	5.02 ± 0.39	5.09 ± 0.41	1.38	4.38	4.42	5.02	5.09	5.66	5.76

sample and the percentile values may be computed considering the measured values of men and women. The results have been presented in table3. Personalized tools are desirable when they are used by one person alone. When a number of workers use them computation of population data is essential because people differ significantly in their anthropometric characteri-stics (Okunribido, 2000). The percentile values shown in table 3, may be used for designing com-mon agrcultural hand tools like, weed spade, si-ckle, paddy pullar, straw pullar, hoe, hand power tiller etc. for indian workers particularly for Eastern India.

The hand dimensions of the population was also studied by different investigators (An et al., 1979; Schmidtke, 1984; Snow, 1984). India is a vast country with a very large population. The hand dimensions of agricultural workers in different parts of India may be different. Therefore a comparison of some hand dimensions between the present study (Eastern India) and the study done by Gite and Yadav (Central India, 1989) has been made and they have been shown in table 4. A little di-fference in the percentile values of hand dime-nsions was observed between the people of two regions. The 't' test was performed to find the level of significance of differene between two gr-oup means (Table 4) and it was noted that there was significant differences in mean values between Eastern India and Central India. Such regional variation in anthropometric diemnsions was also observed in other countries (Chapanis, 1974 and Demon et al., 1966). Differences have been found in different climatic region (Roberts, 1975), in different altitudes and between rural and urban areas (Majumdar et al., 1986). The comparison of data between Eastern and Central India was made for male subjects because the hand dimensions of only male subjects were available from Central India.

A comparison of some hand dimensions of female workers of the present study (Indian) was made with that of Korean (Fernandez et al., 1989) and Nigerian (Okunribido, 2000) subjects which have been shown in table 5. It was noted that the hand dimensions of industrial workers (Korean) were significantly different (P<0.001) with the respect to the values of the agricultural workers (Indian). Except the maximum hand breadth, the other two dimensions of farm workers (Nigerian) were also significantly different (P<0.001) with the respect to the present values. Anthropometric data have revealed difference, amongst age groups, occupational groups (Mebarki and Davies, 1990) and also different countries (Fernandez et al., 1989).

Table 6 contains different hand dimensions expressed as proportions of hand length which were calculated from the data of the present study

Table 5: Comparison of different hand dimensions of female workers among Korean (Fernandez, 1989), Nigerian (Okunribido, 2000) and Present Study (Indian) in cm

Dimension	*Korean (n=101) Mean ± SD*	*Nigerian (n=37) Mean ± SD*	*Present study (n=204) Mean ± SD*
Hand Length	17.00* ± 0.07	17.51* ± 1.11	16.09 ± 0.70
Hand breadth	7.70* ± 0.40	-	7.30 ± 0.35
Maximum hand breadth	9.00* ± 0.40	8.79 ± 0.50	8.75 ± 0.42
Hand thickness	3.00* ± 0.20	-	2.58 ± 0.18
Hand circumference	-	23.30* ± 1.38	17.80 ± 0.95

*p<0.001 w.r.t. the values of the present study

Table 4: Comparison of hand dimensions of male agricultural workers between Central India (Gite and Yadav, 1989) and Eastern India (Present Study) in cm (CI: Central India, EI: Eastern India)

Dimensions	*5th percentile*		*50th percentile*		*95th percentile*		*Mean ± SD*		*'t'*
	CI	*EI*	*CI*	*EI*	*CI*	*EI*	*CI*	*EI*	*Values*
Hand length	16.9	16.1	18.1	17.5	19.6	18.9	18.1 ± 0.84	17.5 ± 0.85	4.04**
Palm length	9.6	8.7	10.1	9.7	11.4	10.8	10.1 ± 0.67	9.7 ± 0.64	3.54**
Hand breadth	7.7	7.5	8.3	8.2	8.9	9.0	8.3 ± 0.36	8.2 ± 0.44	1.33
Maximum hand bredth	9.7	9.0	10.2	9.8	10.7	10.7	10.2 ± 0.38	9.8 ± 0.53	4.54**
Hand thickness	2.3	2.5	2.7	2.8	3.2	3.2	2.7 ± 1.27	2.8 ± 0.21	2.59*
Hnad circumference	18.6	17.9	20.0	19.4	21.2	21.0	20.0 ± 0.81	19.4 ± 1.33	3.76**
Maximum hand circumference	22.1	24.2	23.5	26.4	24.9	28.5	23.5 ± 0.87	26.4 ± 1.33	13.08**
Grip diameter (inside)	3.6	4.64	4.1	5.2	4.6	5.8	4.1 ± 0.30	5.2 ± 0.36	17.91**

Table 6: Different hand dimensions expressed as proportion of hand length

Dimensions	*Proprtion of hand length*	
	Gite & Yadav (1989)	*Present Study*
Palm length	0.563	0.555
Hand breadth	0.454	0.470
Maximum hand breadth	0.557	0.561
Hand thickness	0.153	0.160
Hand circumference	1.055	1.110
Maximum hand circumference	1.284	1.505
Grip diameter (inside)	0.224	0.299

and the corresponding values of proprtion as given by Gite and Yadav (1989) for farm workers of Central India are also shown. It was noted that if the hand length was known, other dimensions could be available from this proportion. Barkla (1961) used this method for the design of seat. The proportion of different hand dimensions had little or no difference between the workers of a Central India and Eastern India.

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KEY WORDS Hand Anthropometry. Agriculture. Design Purpose. Hand Equipment.

ABSTRACT Use of hand anthropometric data can help in the proper designing of equipment for better efficiency and more human comfort. In present study different hand dimensions of right and left hand of the agricultural workers (Male: 200; Female: 204) have been collected from West Bengal state, Eastern India. Eight hand dimensions have been identified which were considered more useful for designing agrcultural hand tools. It has noted that there were significant differences ($P<0.001$) in hand measurements between right and left hands as well as between male and female agricultural workers. However, the percentage of differences in the measurements between right and left hands was small (0.10% to 3.49%) than those between men and women (7.1% to 11.96%) Percentile values (5th, 50th, 95th) of the anthropometric dimensions were computed separately for men and women. The agricultural hand tools can be designed for male and female workers separately using these percentile values. However, it was the common practice of the worker to use the same hand tools by the both sexes. Therefore, percentile values for the hand dimensions were also computed considering the men and women as a single group. The hand dimensions of the subjects of present study were compared with the farmers of central part of India. Some proportions of hand dimensions were also computed.

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