ANTHROPOMETRIC CONSIDERATION OF HAND TOOLS DESIGN FOR NIGERIAN POLYTECHNIC STUDENTS

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ABSTRACT

This study presents anthropometric consideration of hand tools design for Nigerian Polytechnic Students. Nine dimensions relevant to the design of hand equipment were measured from 800 respondents within the age limit of 18 to 30 years. The result of statistical analyses showed significant differences between the dimensions of male and female students on hand length, hand breadth of metacarpal and grip diameter (inside), where those of males were larger. The comparison of the results of some hand dimensions of this study with the results of two other studies from different regions in Nigeria between two genders indicate differences among people in the regions. Mean values of most of the dimensions of Nigerians were found to be smaller when compared to four ethnic population of the world. The variations in hand dimensions should be considered and as well enlarge sample measurements to encompass students in other tertiary institutions in Nigeria.

KEYWORDS: Polytechnic students, hand tools, anthropometric dimensions, equipment.

1. INTRODUCTION

Ergonomics is the application of measurements to products, in order to improve their human use. Ergonomics often involves research into the way people interact with products and the environment around them. Anthropometric data is used to determine the size, shape and / or form of a product, making it more comfortable for human to use and easier to use. In Nigeria, majority of polytechnic students' workforce engage in different activities that involve hands. They devote many hours using hands to write, operate and construct machines, work in agricultural fields, type with computers etc, but no recognition has been given to their hand dimensions in the design of those facilities and machines being used.

Anthropometric body dimensions play a significant role in human-machine and environmental interaction. The overall working efficiency of human-machine environment and resultant discomfort has severe impact while using tools and machinery in different work conditions. Anthropometric data have wide range of applications in the design of agricultural machinery among other physical equipment and facilities. It is needed in the design of products as it varies between individuals and nations. Many western and developing countries like Indian have been making frantic efforts in establishing an anthropometric database for different population groups such as agricultural workers, industrial workers, students, military personnel, civilians, drivers among others. Ethnic diversity is always a significant factor that may affect the anthropometric data and the scopes of its applications. Pleasant (1996) suggested that the variations of body dimensions of different groups can be observed in terms of overall body size and bodily proportions.

Buchholz et al. (1992) reported that the interaction of handle size and shape with kinematics and anthropometry of hand have a great effect on hand posture and grip strength. Furthermore, (Loslever and Ranaivosoa 1993; Chandra et al. 2009; Claudon 2000) have discussed that poor ergonomic hand tools designed is well known factor contributing to biomechanical stresses and increasing the risk of cumulative trauma and carpal tunnel of syndrome disorders of users. Thus, the use of hand anthropometric data in the design of hand tools may constitute better performance of work and reduce undue stresses to the users/operators. Hand anthropometric data and its application in the design of hand fittings are generally scanty in developing countries (Gite and Yadav 1989; Nag et al. 2003;

Imrhan and Contreras 2005; Mandahawi et al. 2008; Imrhan et al. 2009; Chandra et al. 2011). Hand tools need to fit contours of hand, they need to be held securely with suitable wrist and arm posture, they may be utilizing strength and energy capabilities without over loading the body.

Das and Bhattacharya (1984) investigated the optimum design and location of a hand operated rotary device and concluded that though all body dimensions are related to each other, shoulder height and forward arm reach had direct bearing on the design parameters of the rotary device. The grip dimension of most of the hand tools such as knob, weeders, handle of wheel hoe, handle and length of cutlass among others are not properly designed and needed to be designed based on the anthropometric dimensions of the intending users otherwise the machine will be a mismatch to both the users and environment. However, in case of implements that fall within wheel hoe, which has certain working depth, necessary correction needs to be made in handle height to have comfortable holding height in working condition.

The study was carried out to generate hand anthropometric data of Nigerian Polytechnic Students to serve as a database for designing of hand tools and other human facilities that needed hand operations for Nigeria use.

2. MATERIALS AND METHODS

2.1 Subjects

Samples used in our study were conducted from January, 2012 to March, 2013 using 800 subjects (400 males and 400 females) within the age of 18 – 30 years. 200 students (male and female) were selected from each of the four polytechnics (Auchi, Ogwashi-uku, Ozoro and Bori) situated at Edo, Delta and Rivers states respectively by simple random sampling.

Nine hand anthropometric dimensions relevant to the design of hand tools were measured as described in Table1. Students were selected according to their availability and willingness to participate without reward in the form of cash or kind, because they were earlier furnished with the objectives of the study. The methods of hand anthropometric measurements were same as stated by (Davies 1980; Courtney and Ng 1984).

Table 1: Showing definition of some hand dimensions used in the Study

S/N	Dimensions	Definition
1	Functional arm reach	Horizontal distance from the shoulder to the tip of the longest finger.
2.	Hand length	The straight distance between root of the palm and tip of the middle finger.
3.	Hand breadth of metacarpal	The breadth of the palm measurement at the level of maximum bulge of the palm excluding thumb.
4.	Hand thickness	The thickness of the hand measured at the level of middle portion of the palm transversely.
5.	Maximum hand breadth	The breadth of the hand measurement at the level of maximum bulge of the palm including thumb.
6.	Hand circumference	The closed measurement that follows a hand contour at the maximum feast level, the measurement is not circular.
7.	Maximum hand circumference	The closed measurement that follows a hand conotur at the maximum feast level, the measurement is not circular.
8.	Palm length	The straight distance between root of the palm and root of the middle finger.
9.	Grip diameter	Maximum inner curvature of the hand at the touching level between tip of the middle finger and thumb.

2.2 Apparatus

Regular measurement tools were used as anthropometer for stature measurement, arm length measurement and elbow length measurement; and digital Vernier Caliper for length, breadth and depth measurement of hand, measuring tape for circumferential measurements, a wooden cone designed locally and specially to measure internal grip diameter and inner caliper for measurement of grip span.

2.3 Statistical Analysis

Mean ± SD and key percentiles were measured for each dimension. The measurements were compared between male and female genders. Data was analyzed using independent samples t – test by SPSS (Version 18.0).

3. RESULTS AND DISCUSSION

Table 2 shows the summary of the results of nine hand anthropometric data of 400 male and 400 female students of Nigerian Polytechnics in terms of means, standard deviations, fifth, fiftieth, and ninety-five percentile. The findings indicate that the mean dimensions of the subjects can be used as a reference database for designing different hand tools and fittings for the students in the area. Apart from mean, 5^{th} and 95^{th} percentile values of their body dimensions were calculated to decide various possible design limits of hand tools, handles, control panels and workplace layout to be operated by each group.

Table 2: Anthropometric Dimensions of Male and Female Nigerian Polytechnic Students

	Male					Female				
Body dimension (cm)	Mean	SD	Percentiles			Mean	SD	Percentiles		
			5^{th}	50^{th}	95^{th}			5^{th}	50^{th}	95^{th}
Functional Arm Reach	72.2	8.0	51.6	73.7	81.4	66.1	12.8	49.4	64.5	88.8
Hand Length	16.6	1.4	15.1	17.9	20.0	15.6	1.4	12.7	15.5	17.8
Hand Breadth of Metacarpal	9.6	1.5	7.6	9.3	12.7	8.8	1.2	7.3	8.9	11.1
Hand Thickness	2.9	0.25	2.5	2.7	3.1	2.8	0.21	2.4	2.8	3.0
Maximum Hand Breadth	11.3	1.9	6.0	11.3	14.2	10.8	1.9	8.1	10.5	14.2
Hand Circumference	18.1	3.4	12.3	18.9	22.8	16.9	3.2	10.2	17.8	20.3
Maximum hand circumference	24.1	1.2	22.4	24.0	25.9	23.5	1.3	21.4	23.4	s25.2
Palm Length	11.6	1.4	10.0	11.6	14.3	11.4	1.2	9.7	11.4	13.8
Grip Diameter (inside)	5.3	0.9	3.5	5.2	6.6	4.8	0.6	2.6	3.2	4.3
Grip Diameter (outside)	7.6	0.8	6.5	7.6	9.9	6.3	2.0	6.1	7.6	13.3

The results of statistical t–test comparison of hand anthropometric dimensions of the male and female data are presented in Table 3. The test results proved significant differences between the hand dimensions of male and those of their female counterparts on hand length, hand breadth of metacarpal and grip diameter (inside), where those of male were larger. The percentage of difference in hand dimensions (males and females) ranged from 1.56 % to 17.11%. Considering the data obtained (Table 3), the design of hand tools having the same dimensions for both male and female may be adopted in the area except in the design of hand tools on those dimensions that were statistically significant.

Table 3: T-Test analysis of Male and Female Anthropometric dimensions of Nigerian Polytechnic Students

Body Dimensions (cm)	Mean Male	Mean Female	N	Tcal	Df	Sig.(2-tailed)	Decision p<0.05
Functional Arm Reach	72.2	66.1	800	-1.626	799	0.120	NS
Hand Length	16.6	15.6	800	-4.413	799	0.000	S
Hand Breadth of Metacarpal	9.6	8.8	800	2.064	799	0.053	S
Elbow Hand Grip	12.8	12.6	800	0.473	799	0.641	NS
Hand Thickness	2.9	2.8	800	1.375	799	0.185	NS
Maximum Hand Breadth	11.3	10.8	800	-1.11	799	0.281	NS
Hand Circumference	18.1	16.9	800	1.00	799	0.330	NS
Maximum Hand Circumference	24.1	23.5	800	0.945	799	0.376	NS
Palm Length	11.6	11.4	800	0.82	799	0.422	NS
Grip Diameter(inside)	5.3	4.8	800	6.636	799	0.000	S
Grip Diameter(outside)	7.6	6.3	800	-1.734	799	0.099	NS

S and NS means significant and not significant respectively.

Figs. 1 and 2 show the comparison of the results of some hand dimensions of our study with the results of two other studies from different regions in Nigeria between two genders. All dimensions from each study were larger in males than females.

The results of the comparison also reveal that hand dimensions of present study (south south region) are almost lower in all dimensions for both gender, when compared to Onuoha et al. 2012(south eastern region); whereas the mean values of present study were higher than Ismaila et al. 2010 (south western region). The values of mean in each study as represented in Figs 1 and 2 showed increases in hand dimensions in middle age before declining with an increasing age. This classification revealed that there are clear difference among the three groups; and as such indicating a unique and distinct nature of hand anthropometry of Nigerian population.

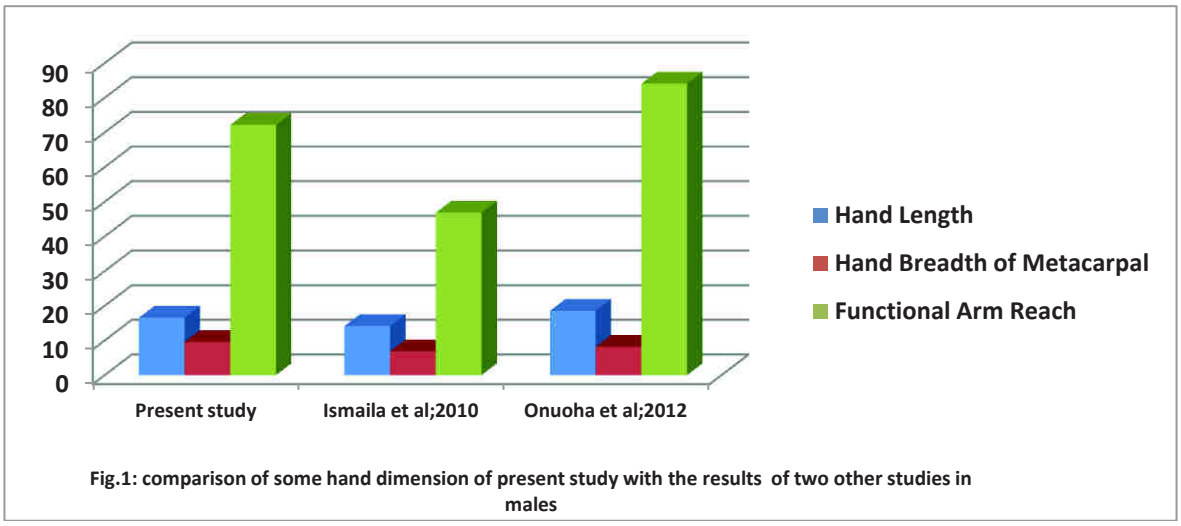

Fig.1: comparison of some hand dimension of present study with the results of two other studies in males

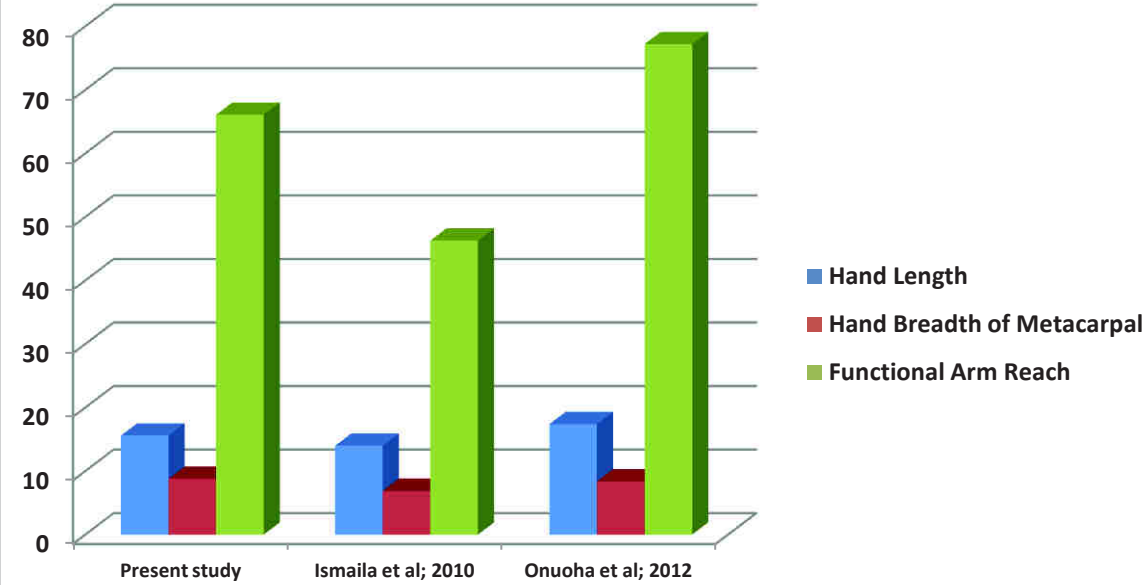

Fig.2: Cmoparison of some hand dimension of present study with the results of two other studies in females

The mean dimensions for males and females of three ethnic populations of the world were compared with the present study as presented in Table 4.

The empty data cells (DNA) are due to data being unavailable. Simple analysis was used to compare the significance of mean differences among these four ethnic populations of the world. The test results showed that there are significant differences in most of the mean dimensions.

Among the male group, present study has the lowest mean values of hand length, forward grip reach and hand thickness but has the largest mean values of hand breadth of metacarpal when compared to other ethnic populations. More so, United State of America (USA) has the largest values in all the hand dimensions except that of hand breadth of metacarpal. Similar trend were observed among female group where some variations in the mean values of Nigerian (present study) were largest for hand length and hand thickness; and lowest for hand breadth and forward grip reach respectively. Hereditary influences, economic development, social environment, type of work and labour structure all affect the ethnic differences in body shape (Lin et al. 2004). These differences should be considered for designing and buying of hand operated machines/fittings to be used by the studied subjects.

Table 4: Comparison of hand anthropometric dimensions of male and female Nigerian Polytechnic Students with other ethnic population of the world

	Male								Female							
	Present study (Nigeria)		Chinese (Karmega et al. 2011)		USA (Hsiao et al. 2005)		Indian ((Kar et al. 2003)		Present study (Nigeria)		Chinese (Karmega et al. 2011)		USA (Hsiao et al. 2005)		Indian (Kar et al 2003)	
Dimension (cm)	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Hand Length	17.60	1.40	18.22	1.33	19.7	1.0	17.50	0.85	15.60	1.4	17.17	1.13	18.20	0.90	16.09	0.70
Hand Breadth of Metacarpal	9.60	1.5	6.90	0.58	9.1	0.5	8.23	0.44	8.80	1.2	6.90	0.79	8.00	0.50	7.30	0.35
Forward Grip Reach	72.20	8.00	74.07	5.27	75.80	3.70	DNA	DNA	66.1	12.8	66.26	3.61	69.2	3.70	DNA	DNA
Hand Thicknes	2.90	0.25	2.95	0.33	3.00	0.20	2.81	0.28	2.8	0.21	2.36	0.26	2.50	0.20	2.58	0.18

DNA means Data not available

4. CONCLUSION AND RECOMMENDATIONS

The statistical t-test comparison of the results of hand anthropometric dimensions between males and females students showed significant differences on hand length, hand breadth of metacarpal, hand circumference and grip diameter (inside), where those of males were larger. The results of some hand dimensions of the present study was compared with the dimensions of Onuoha et al. 2012 (South eastern-Nigerian agricultural workers) and Ismaila. 2010 (South western – Nigerian passengers seated in buses) between two genders showed that all dimensions from each study were significantly larger in males than females. Hand dimensions of the present study were almost smaller for both genders when compared to Onuoha et al. 2012; whereas the mean values of the present study were larger than Ismaila et al. 2010.

The mean values of the study showed increase in hand dimensions in middle age before declining with an increasing age. These data will be useful for the engineers and scientists to decide various possible design limits of hand operated machines, hand hoes, control panel, work station, hand apparel and other hand held devices. Mean values of most of the hand anthropometric dimensions of Nigerian (present study) were found to be smaller when compared to other ethnic populations of the world.

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