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Anthropometry Survey of People with Limbs Impairment as a Basis for Equipment and Machinery Development in Nigeria

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Abstract:- In Nigeria people with functional limitation in the usage of limbs among others are regarded as being incapable of contributing to the growth and the development of the society, but are relegated to be beggars on the streets. This is a great waste of human resources in this age of technological innovations! Use of anthropometric data may help in the proper design of local equipment and machinery for this group of disability for better efficiency and more human comfort. Therefore, selected body dimensions necessary for the design of these equipment were identified and a sample study was conducted on 50 men with limbs impairment, in which 40are with lower limbs impairment and 10 are with upper limbs impairment. The collected anthropometric data were analysed to calculate mean, standard deviation, variance, maximum and minimum values, and 1th, 5th, 50th, 95th, and 99th percentile values. Through the analyses of variance at $\alpha = 0.05$, it is discovered that nature of limb impairment is not significant with age (P-value =0.404), however it is significant with body weight (P-value = 0.00) having R^2 to be 1.46% and 32.45% respectively. It has now been proposed that extensive surveys should be carried out on people with limbs impairment in different regions of the country to generate the necessary data useful in farm machinery design/design modifications.

Keywords:- Anthropometry, limbs impairment, agro-processing, design, machine development

I. INTRODUCTION

The costs of importation of agricultural machinery have lead to greater demand and development of locally fabricated machines and devices used in agro-processing. In effect, these pressures have geared up increase level of interaction between man and machines, however, these machines lack human factors considerations. In the design and production of every product, consideration should be given to the product's impact on the end users, in terms of their accessibility, affordability and comfort. As described by [1], [2] anthropometric data are one of essential factors in designing machines and devices. Also, [3] submitted that the study of human body measurement is used in engineering to ensure the maximum benefit and capability of products that people use. To use anthropometry knowledge effectively, it is also important to have knowledge of the relationships between the body and the items worn or used.

Besides cost, another salient factor of necessity is that imported machineries are not designed based on our own anthropometry diversity, rather the producers' home countries. Hence there is a timely need for our own reliable anthropometry data bank that cut across the able and disabled people in Nigeria to break loose from all forms of mismatches that are only identified by a few, whereas all surfers the consequences. [4] Reported that people come in a great variety of sizes and the proportions of their body parts are not the same. To have a safe work environment, designers should account for the variations in the anthropometrics of the workforce [5]. The ideal design of any workplace should begin with the operator's in mind. The design should ensure that the operator will have adequate and comfortable posture that he can see what he must and he can operate his control in an effective manner. If the workplace is not properly adapted to his dimensions and to his typically human characteristics, he will not be able to perform his work with maximum efficiency, [6].

[7] Said that the development of machine for the disable will lead to empowering them off the street and make them skilful and useful in the environment they are. Agriculture help in reducing extreme poverty and hunger from the disabled, through engaging them in agriculture, as they will be employed, and at the same time creates income generation for self-reliance, [8]. An improved design on the locally developed existing processing machinery, ergonomically adaptable to accommodate physically challenged, and non-sex bias in agro-processing sector can be a remarkable breakthrough, and may open doors to vast untapped potentials, control beggars asking for arms on our highways, significantly enhance human labor productivity and make Nigeria one of the major players at the global level for marketing and supply of processed food, feed and a wide range of other plants and animal products.

This study is aimed at making available an anthropometric data of people with limbs impairment (upper limbs or lower limbs) in other to make them productive as agricultural workers in the country so as to ascertain the ergonomic design and modifications of agricultural equipment and machineries suitable for their use.

II. MATERIALS AND METHOD

Measurements were taken from randomly selected 50 male street beggars having the age range of 25-50 years. The subjects covered under the random survey were people (Hausa) with either upper limb(s) or lower limb(s) impairment. The questionnaire was used to collect data from them and the anthropometric measurement was carried out. Due to language barrier, an interpreter was employed and materials such as digital weighing balance (Precision screen gauge sensor system, capacity (150kg), decision (100kg) LCD (1.0 inches)), anthropometer, and ruler, measuring tape, stadiometer and caliper were used to measure the anthropometric parameters of the subjects alongside with these is carpenter's inclinometer, a recorder and record book. The reference point for all vertical measurements is ground (floor) level, while the wall is reference point for all horizontal measurements; all measurements except weight are in centimeters (cm). 20 body dimensions were measured which are obtained manually and they include; body weight, acromion height(sitting*), acromion to fingertip, arm length, bideltoid breath, buttock to heel length, buttock to popliteal length, elbow to fingertip, elbow height, eyes height(sitting*), eyes height (standing), hand length, hand width (Metatarsal), hand width with thumb, maximum body width, grip reach, reach forward(sitting), overhead reach(sitting*), overhead reach(standing*), foot length, foot breath, reach forward(standing*), standing height, and sitting* height.

2.1. Measuring Techniques

The Body Size Descriptors: These measurements serve as basic population descriptors and are applied in the design of workspaces and the immediate physical environment, as well as the sizing of personal items and equipment. Except for body weight, this group of measurements is made up of simple point-to-point distances in one or another of the principal body axes.

Reach: For reach measurements, this is concerned with "hand reach to, leg reach to, and actuation of, controls." The functional reach dimensions as listed are measured in the traditional way by keeping the back, shoulder, and buttocks against the wall and stretching the arm along a scaled metal rule (to the thumb tip, center of hand fold, foot heel).

2.2. Data Analysis Methods

The data presented in this study were analyzed using minitab Mtb EXE (version 14.1.0.0) and SPSS statistical package (version 14.0). ANOVA (analyses of variance) using adjusted SS for test and descriptive statistics (mean, standard deviation, variance, minimum and maximum values and 5th, 50th and 95th percentiles) are stated.

III. RESULT AND DISCUSSIONS

The general characteristic of the subjects (age, body weight, and type of limbs impairment) are as presented in Table 1. A summary of the anthropometry measurements (mean, standard deviation, and range, variance minimum and maximum) for the 2 focused impairment as given in Table 2. Table 3a and 3b show the percentile values (1st, 5th, 50th, 95th and 99th) for each dimension for entire limbs impairment. The summary of the Analysis of Variance (ANOVA) on the effect of the specified impairment for age and weight is as shown in Tables 4b and 4b respectively.

Table 1: General Characteristic of Subjects

S/N	Age (year)	Body Weight (kg)	Limbs Impairment		S/N	Age (year)	Body Weight (kg)	Limbs Impairment
1	37	46	lower		26	40	44	lower
2	40	45	lower		27	37	51	lower
3	31	53	lower		28	37	44	lower
4	50	42	lower		29	36	46	lower
5	30	45	lower		30	41	40	lower
6	29	43	lower		31	50	43	lower
7	30	58	upper		32	45	45	lower
8	40	52	upper		33	38	45	lower
9	25	39	lower		34	30	35	lower
10	30	61	upper		35	25	51	lower
11	41	38	lower		36	30	45	lower
12	30	44	lower		37	30	42	upper
13	45	78	upper		38	37	48	lower
14	27	36	lower		39	49	40	lower
15	30	50	lower		40	27	55	upper
16	25	46	lower		41	33	47	lower
17	30	43	lower		42	30	50	lower
18	30	40	lower		43	34	51	upper
19	25	35	lower		44	38	45	lower
20	34	46	upper		45	40	43.5	lower
21	25	52	lower		46	42	50	lower
22	28	56	upper		47	48	45	lower
23	40	53	lower		48	35	52	upper
24	35	42	lower		49	36	46	lower
25	36	30	lower		50	36	50	upper

Upper =10 lower = 40

A summary of the general characteristics of the subjects randomly selected for study indicates that 40 men are lower limbs impaired and 10 men are upper limbs impaired, the weight ranged from 30 kg for lower limbs impairment to 78 kg for upper limbs impairment (Table 1). The descriptive statistics for the measured anthropometric parameters in Table 2 shows that the minimum values of some parameters are zero (0), this indicates the consideration of the totality of the focused limbs impairments for single machine design and fabrication.

Table 2: Descriptive Statistics for the Measured Anthropometric Parameters

Anthropometric Parameters	Mean	SD	Variance	Range	Minimum	Maximum
Weight	46.53	7.60	57.76	48.00	30.00	78.00
acromion height(sitting)	63.41	13.83	191.27	83.00	0.00	83.00
acromion to finger tip	84.51	8.88	78.85	46.00	52.00	98.00
arm length	84.91	9.04	81.72	46.50	52.00	98.50
bideltoid breath	41.38	2.62	6.86	15.90	35.10	51.00
buttock to heel length	24.47	46.64	2175.28	124.00	0.00	124.00
buttock to popliteal length	53.36	13.01	169.26	78.10	0.00	78.10
elbow to finger tip	49.31	3.59	12.89	22.40	37.00	59.40
elbow height	21.52	4.83	23.33	28.00	13.00	41.00
eyes height(sitting)	62.85	7.48	55.95	34.90	44.10	79.00
eyes height standing	37.08	66.81	4463.58	167.20	0.00	167.20
hand length	19.25	0.88	0.77	5.10	17.00	22.10
hand width (Metatarsal)	19.33	0.85	0.72	22.10	18.96	0.98
hand width with thumb	7.89	0.98	0.96	11.50	7.74	0.32
maximum body width	43.67	3.07	9.42	14.30	36.70	51.00
grip reach	76.91	8.52	72.59	61.50	30.50	92.00
reach forward(sitting)	85.36	7.85	61.62	46.30	52.20	98.50
overhead reach(sitting)	129.26	23.58	556.02	190.50	0.00	190.50
overhead reach(standing)	46.41	88.43	7819.86	222.00	0.00	222.00
foot length	5.48	9.87	97.42	25.40	0.00	25.40
foot breath	2.21	3.99	15.92	10.20	0.00	10.20
reach forward(standing)	19.72	37.58	1412.26	97.00	0.00	97.00
standing height	38.85	69.98	4897.20	174.60	0.00	174.60
sitting height	64.60	16.81	282.58	88.70	0.00	88.70

All measurement is in (mm), but weight is in (kg)   0.00 values indicates either no lower limbs or upper limbs

Table 3a and 3b show the percentile values (1st, 5th, 50th, 95th and 99th) for each dimension for both types of impairment. The extremes (1st, 5th and 95th, 99th percentiles) should be of interest in the designing of equipment since they influence fit and comfort. These percentiles are capable of accommodating 90% to 99% of the focused group and may also be used for comparison with those published for the able populations.

Table 3a: Percentile Value for People with Lower Limbs Impairment (PWLLI) (measurement in mm)

Anthropometric Parameter	Percentiles				
	1st	5th	50th	95th	99th
weight*	31.90	35.00	45.00	52.10	53.00
acromion height(sitting)	39.02	45.59	64.20	77.05	80.89
acromion to finger tip	52.08	72.72	86.10	95.14	97.05
arm length	52.08	72.72	86.50	95.48	98.31
bideltoid breath	35.63	37.85	41.90	45.08	49.02
buttock to popliteal length	41.19	44.82	55.00	61.38	62.60
elbow to finger tip	39.28	44.80	49.20	55.29	58.15
elbow height	13.00	13.90	20.00	28.69	30.43
eyes height(sitting)	44.44	49.86	62.00	74.32	78.32
hand length	17.30	18.38	19.40	20.20	21.72
hand width (Metatarsal)	6.81	7.09	7.60	9.93	11.35
hand width with thumb	7.88	8.00	9.00	10.70	12.56
maximum body width	39.00	39.94	43.50	49.99	50.92
grip reach (sitting)	45.51	70.45	76.30	86.11	88.46
reach forward(sitting)	60.67	74.95	86.50	95.48	99.31
overhead reach(sitting)	85.39	118.83	131.70	145.23	177.37
sitting height	41.70	48.50	66.30	82.70	86.8333

*** The measurement is in kilograms (kg)**

Closely look at the parameters they shared in Table 3a and 3b, such as sitting height, maximum body width, eyes height (sitting), bideltoid breath, acromion height (sitting) and weight one could deduced that there is relatively small percentile values differences. These suggest that a single machine can accommodates any person from either focused functional limitation without a wide range of adjustment. The higher weight of people with upper limps impairment was not unexpected. The differences in 1st and 99th percentiles ranged from 10.5 to 23.3 depending on the variations in level of deformation.

Table 3b: Percentile Value for People with Upper Limbs Impairment (UWLLI) (measurement in mm)

Anthropometry Parameter	Percentiles				
	1st	5th	50th	95th	99tth
weight*	42.40	44.00	52.00	69.50	76.30
acromion height(sitting)	59.48	59.80	73.50	80.30	81.34
bideltoid breath	36.69	37.05	41.20	43.30	43.46
buttock to heel length	103.14	103.70	110.5	121.5	123.50
eyes height(sitting)	55.50	57.50	69.00	73.55	75.51
eyes height standing	136.53	138.65	153.50	166.10	166.98
maximum body width	36.93	37.85	43.00	48.05	48.81
foot length	21.14	21.30	22.40	25.20	25.36
foot breath	8.32	8.40	9.00	10.10	10.18
standing height	139.32	144.6	163.20	173.65	174.41
sitting height	64.14	64.70	75.60	80.00	80.00

*** The measurement is in kg**

The Analysis of Variance (ANOVA) indicates that the nature of disability has a highly significant effect ($P < 0.05$) on body weight while the effect of nature of disability was found to be non-significant on age (Tables 4a and 4b). The independent factors are nature of impairments while age and weight are considered as dependent variables.

Table 4a:. Analysis of Variance for Age, Using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Limbs Impairment	1	33.62	33.62	33.62	0.71	0.404
Error	48	2275.20	2275.20	47.40		
Total	49	2308.82				

S = 6.88477 R-Sq = 1.46% R-Sq(adj) = 0.00%

Table 4b: Analysis of Variance for Body Weight, Using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Limbs Impairment	1	918.06	918.06	918.06	23.06	0.000
Error	48	1911.14	1911.14	39.82		
Total	49	2829.21				

S = 6.30995 R-Sq = 32.45% R-Sq(adj) = 31.04%

IV. CONCLUSIONS AND RECOMENDATION

The study had revealed the variations in anthropometry parameters of people with limbs impairment among the Hausa tribe in the country. It could be deduced that the nature of the analysed results may be useful for accommodation and comfort at workstation through the application of ergonomic designs: design for reach, design for adjustability, and design for extremity.

Based on the results from the investigation, and the sample size, it is recommended that in order to standardise and validate database that will be useful for equipment and machinery development for the focused people in the entire country, the study must be conducted across the tribes in the country.

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