Body Segment Dimensions of Adult Craftsmen of Benin Origin

O.L. Akangbe[1], O.O. Ejofodomi[2], O.N. Aibangbee[2] and F.O. Ajayi[3]

[1]Department of Agricultural and Bioresource Engineering, Abubakar TafawaBalewa University, P.M.B. 0248 Bauchi, Bauchi State, Nigeria. olaosebikanakangbe@yahoo.com; olakangbe@atbu.edu.ng

[2]Department of Mechanical Engineering, Igbinedion University, Okada, P.M.B. 0006, Benin City, Edo State, Nigeria.

[3]Mechanical and Mechatronics Engineering Department, Faculty of Engineering, Federal University, Oye-Ekiti, Ekiti State.

ABSTRACT

Anthropometric data or measures of the human individual play very important roles in the design and development of equipment suited to target user populations and are invaluable in product optimization. Very little is reported on anthropometric data of human subjects of Nigerian origin, hence the need to develop valid anthropometric database for target user groups in Nigeria on a systematic basis. Body segment dimensions and masses of adult craftsmen within the Benin area of Nigeria were generated through a field survey involving a representative 180 subject sample size drawn from an estimated 1250 craftsmen population within the study area using standard techniques. Data generated from three local government areas in the study area were compared using variance ratios and t-statistics. Comparison was also made between these data and those generated using an established (Winter's) model. Significant differences in size ($p<0.05$) were established for subjects from the three local areas within Benin. Subjects from Egor locality had significantly larger size indications for only some of the segment parameters studied; this did not represent a general trend for all body segments studied. There were marked deviations from observed mean values for 19 of the body segment parameters generated using Winter's model, at probabilities ranging between 0.05 and less than 0.01, except for mean shoulder breadth, wrist height above datum and foot length which were similar to the observed field values at p-values of 0.59, 0.15 and 0.11, respectively. This means that the new models generated for each of the local government areas and Benin City are more suited to predicting body segment dimensions in the study area.

KEYWORDS: Anthropometry, Body Segment Lengths, Craftsmen, Benin, Nigeria

1. INTRODUCTION

Static and functional measurements of human body segment lengths are widely applied. In engineering, they are employed with respect to the design of machines or machine components, work and work spaces, buildings, etc. One of the career domains within which anthropometry has been used extensively is military engineering [1]. However, Human Factor issues will always arise where people interact with technology products [2]. Safe and efficient use of equipment in both civilian and military spheres require adequate establishment of compatibility between the equipment and users. Anthropometric data have been shown to vary across age, sex, occupation, ethnic origin and other variables [3-10]. Richard et al. [11] reported comparative increases in population heights of a studied population over time and a possible linkage with immigration trends in the study area. Guided use of anthropometric data is traditional, particularly because of distinct variations of the parameters involved [12] even within selected human populations [13].It is essential to establish design relevant data specific to a target population in order to achieve satisfactory product design.Spatial dimensions of the target user population are often used to determine requirements of the engineered artifact; expected variability in body dimensions is used to indicate how much adjustability or how many sizes are required to accommodate the intended user population [14]. Traditional decisions based on percentile values [15]or ranges to be included or eliminated when making design judgments often result in products or features that are suitable for just a section of the likely user population, however inclusive or large. Attempts at achieving products suited to almost any user population have been reported and some of such products appear to be such as can permit adjustable features [14] with provisions for different users to adjust the equipment to suit their needs [16]. Some equipment or equipment features may not lend easily to such improvisations. Anthropometric models share a basic need for accurate representationof body size, shape, and proportion[2].Decoding human variation is a complex problem, which becomes even more difficult when attempting to characterize large numbers of traits[13]. General acceptation is that there is no such thing as the average representative person[17]. The need for products suited to different user populations necessitates adequate human anthropometric database generation for design purposes. Normally, these data are measurements of the human subject taken between landmarks in various positions, usually standing and sitting, but sometimes prone or supine; heights from the floor, assorted circumferences, body breadths, and depths are recorded. These measurements provide the data necessary to create a numeric representation of the subject[15]. Anthropometric data should be reliable and statistically robust to minimize the introduction of errors during the design of equipment, jobs or workspaces[18]. Chan and Jiao [19] associated work-related fatigue and occupational illness to mismatch of anthropometric dimensions. Reductions in human error and hazards during work are achieved with proper use of anthropometric data [20].

Detailed record of anthropometric data of subjects of Nigerian origin is scanty. This study was informed by a need to develop on a systematic basis valid database of design relevant body segment dimensions and physical characteristics of representative craftsmen population in the Benin area of Nigeria.

2. MATERIALS AND METHODS

2.1. The Study Area

This study was conducted in Benin City, Edo State, Southwestern Nigeria. Benin lies within the longitudes 5°04 and 6°43 E of the Greenwich meridian and latitudes 5°44 and 7°34 N of the equator. The city is comprised of three local government areas, namely Egor, Oredo and IkpobaOkha areas. Benin is renowned as an ancient indigenous crafts centre and boasts skilled artisans and craftsmen in various vocations, including automobile mechanics, electricians and blacksmiths.

2.2. Sampling Technique and Sample Size

Local authorities report an estimated 1250 craftsmen population within the Benin area. An appropriate sample size for this population was computed using the Creative Research Systems' Sample Size Calculator [21] to be 170, based on a confidence interval of 7.0 and a 95% confidence limit. The data reported in this study were generated from 180 human subjects. These subjects were randomly drawn from the three local government areas.

2.3. Procedure and Instrumentation for Anthropometric Measurements

Anthropometric measurements taken were subject body segment lengths and weights, using standard techniques [22]. Twenty three static body segment dimensions (Fig. 1) were generated for each standing subject, in addition to the subject's body mass. The length measurements are linear dimensions between indicated body landmarks for each segment length. In this study, comparisons were drawn between observed field data and the commonly adopted Winter's model for body segment dimensions [22]. Body segment parameters studied are indicated in Tables 1 – 6. Each segment dimension was generated with respect to a datum. Segments 1 – 5 and 15 – 21 were generated with respect to the standing platform while segments 6 – 14 and 22 – 23 were generated with respect to body parts of interest, as reference (Fig. 1). Each Subject's body mass (parameter 24) was obtained using bathroom type scales.

2.4. Data Analysis

All test data were analysed for mean, minimum, maximum, standard deviation and percentile statistics. One-way analysis of variance was run on these data with post-hoc comparisons done across local government groups. Body segment dimensions were then generated using Winter's [22] model based on actual field-generated statures for the 180 subjects sampled for this study and were compared with actual segment dimensions of the subjects using the t-test.

3. RESULTS AND DISCUSSIONS

Body segment dimensions of craftsmen subjects from Egor, Oredo and IkpobaOkha areas of Benin, Nigeria are presented in Tables 1 – 3. Differences in mean foot breadths of subjects from these three areas were not significant ($p=0.06$). However, highly significant differences ($p<0.01$) were observed for mean ankle, knee, pelvic and chest heights above datum of subjects from Egor, Oredo and IkpobaOkha local government areas. Except for trunk breadth ($p=0.294$), highly significant differences ($p<0.001$) were observed between mean values of hip and pelvic breadths of subjects from the three local government areas. Crown, Shoulder to elbow, elbow to wrist and wrist to digit spans were significantly different ($p=0.004$, $p<0.001$, $p=0.002$ and $p<0.001$, respectively) across the local government areas. No significant differences ($p=0.193$) were observed for mean neck to shoulder spans across the three local government areas.

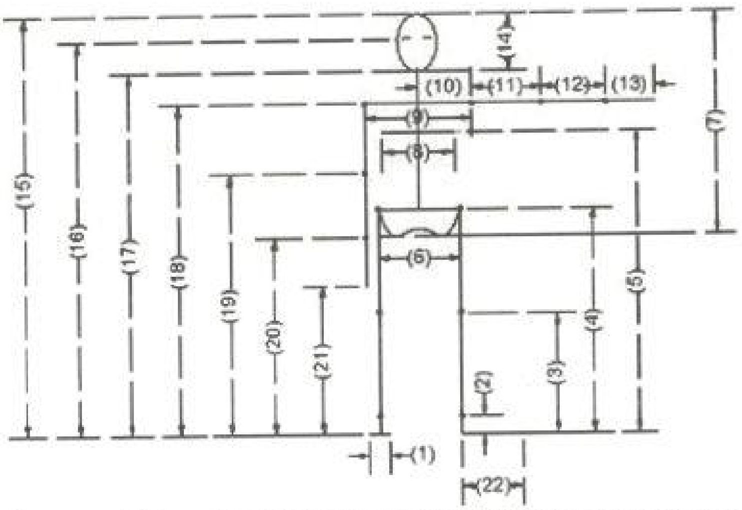

Figure 1: Static body segment dimensions. Body segments are numbered as presented in the results tables

Table 1: Mean body mass and segment lengths of craftsmen from Egor Local Government Area of Edo State, Nigeria

						PERCENTILES	
s/n	**Parameter**	**MIN**	**MAX**	**MEAN**	**SD**	**5TH**	**95TH**
1	Foot Breadth	7.60	13.2	9.26	1.04	8.10	11.2
2	Ankle Height	7.20	11.5	8.94	1.77	7.00	12.2
3	Knee Height	6.70	13.5	52.8	3.50	47.9	57.6
4	Pelvic Height	38.9	59.2	106.4	4.33	101.3	113.4
5	Chest Height	93.9	119.7	137.2	5.88	131.3	145.8
6	Hip Breadth	113.2	148.3	38.2	4.95	31.6	46.0
7	Crown	30.2	48.2	91.7	9.88	85.2	104.2
8	Trunk Breadth	29.3	107.5	34.5	7.16	29.9	41.2
9	Shoulder Breadth	28.9	83.8	48.4	5.33	38.9	55.5
10	Neck to Shoulder	36.4	57.0	19.0	3.17	15.7	23.4
11	Shoulder to Elbow	13.6	35.4	38.5	3.23	33.7	43.5
12	Elbow to Wrist	31.3	45.0	31.5	3.79	26.5	38.1
13	Wrist to Digit	24.5	41.2	22.0	2.42	18.3	25.6
14	Head Length	12.5	29.7	21.9	2.76	17.6	26.2
15	Subject Height	16.4	26.9	181.0	9.40	164.8	191.9
16	Eyes Height	150.2	194.7	165.5	8.74	149.5	175.7
17	Chin Height	139.2	182.9	154.0	9.59	141.5	167.2
18	Shoulder Height	115.2	172.3	139.8	6.25	130.6	150.1
19	Elbow Height	123.7	153.6	115.7	5.79	107.0	125.0
20	Wrist Height	102.6	135.2	90.6	9.37	79.7	111.3
21	Long Digit Height	78.4	112.2	72.8	13.4	54.0	92.8
22	Foot Length	21.2	98.4	27.8	1.39	24.7	29.8
23	Palm Breadth	24.2	29.9	10.2	1.18	8.66	12.1
24	Subject Body Mass	65.0	106.0	83.1	8.33	71.9	99.1

Table 2: Mean body mass and segment lengths of craftsmen from Oredo Local Government Area of Edo State, Nigeria

s/n	Parameter	MIN	MAX	MEAN	SD	PERCENTILES	
						5TH	95TH
1	Foot Breadth	7.90	11.8	9.35	0.78	8.10	10.5
2	Ankle Height	7.60	11.2	8.21	1.19	6.90	10.2
3	Knee Height	6.80	13.4	51.7	2.76	48.0	43.8
4	Pelvic Height	40.6	56.5	103.6	4.29	97.5	109.7
5	Chest Height	91.8	116.7	133.2	6.11	121.5	142.6
6	Hip Breadth	115.6	147.6	35.4	7.27	30.0	41.4
7	Crown	28.7	83.6	85.5	13.6	77.5	97.3
8	Trunk Breadth	8.40	99.6	34.2	14.2	25.3	40.2
9	Shoulder Breadth	23.0	136.8	46.5	6.28	36.8	54.9
10	Neck to Shoulder	31.2	55.6	19.8	2.32	16.8	22.8
11	Shoulder to Elbow	15.8	27.3	35.5	4.78	27.8	42.8
12	Elbow to Wrist	24.8	44.5	29.9	3.50	24.2	35.3
13	Wrist to Digit	23.2	37.8	21.1	2.05	17.3	24.6
14	Head Length	16.1	26.2	21.6	2.69	16.4	25.3
15	Subject Height	15.2	26.8	178.9	9.12	163.3	192.3
16	Eyes Height	150.3	193.7	165.4	8.73	153.3	177.6
17	Chin Height	137.8	179.8	151.8	10.8	130.0	165.4
18	Shoulder Height	115.8	174.2	141.6	8.87	131.6	158.3
19	Elbow Height	113.3	162.4	113.6	6.25	103.3	126.4
20	Wrist Height	98.2	131.3	86.8	9.45	77.2	99.6
21	Long Digit Height	32.9	102.3	71.6	7.85	60.3	83.9
22	Foot Length	56.3	88.7	27.1	1.72	24.3	29.7
23	Palm Breadth	22.9	253	9.76	1.04	8.40	11.5
24	Subject Body Mass	69.0	99.0	82.7	6.98	71.9	94.0

Table 3: Mean body mass and segment lengths of craftsmen from IkpobaOkha Local Government Area of Edo State, Nigeria

s/n	Parameter	MIN	MAX	MEAN	SD	PERCENTILES	
						5TH	95TH
1	Foot Breadth	7.10	12.6	8.96	0.97	7.30	10.6
2	Ankle Height	6.80	11.1	8.37	1.13	7.30	10.3
3	Knee Height	6.90	12.1	50.8	3.19	43.8	54.7
4	Pelvic Height	39.7	56.3	103.7	4.99	97.3	113.8
5	Chest Height	92.7	118.6	133.8	5.90	128.2	141.8
6	Hip Breadth	104.8	145.2	33.8	3.17	28.7	37.8
7	Crown	28.1	43.2	87.5	5.71	78.1	96.9
8	Trunk Breadth	73.5	101.3	36.7	3.03	32.1	41.1
9	Shoulder Breadth	28.9	45.9	43.8	4.07	38.3	50.5
10	Neck to Shoulder	37.5	54.1	19.2	1.87	16.7	22.6
11	Shoulder to Elbow	15.2	23.5	33.9	4.66	25.3	40.3

12	Elbow to Wrist	21.8	41.3	29.2	3.25	24.3	34.9
13	Wrist to Digit	22.8	36.4	20.4	1.84	17.5	23.1
14	Head Length	16.2	25.7	20.5	2.62	16.9	24.9
15	Subject Height	16.4	26.3	178.6	10.0	162.2	191.8
16	Eyes Height	149.3	193.8	163.1	9.56	144.6	176.0
17	Chin Height	138.2	180.3	152.1	8.84	137.6	165.5
18	Shoulder Height	131.9	172.1	139.4	7.34	129.3	156.0
19	Elbow Height	125.4	161.9	113.7	7.37	96.2	125.8
20	Wrist Height	93.8	127.5	87.1	8.04	74.2	104.4
21	Long Digit Height	72.4	112.8	71.7	8.83	60.1	88.7
22	Foot Length	57.2	91.7	26.2	1.77	23.5	29.0
23	Palm Breadth	21.3	29.2	9.33	1.12	7.60	11.2
24	Subject Body Mass	64.0	95.0	79.9	6.11	88.2	88.2

Head length, wrist height above datum and palm breadth were significantly different ($p=0.11$, $p=0.04$ and $p<0.001$, respectively) across the 3 local areas. However, each of subject, shoulder, elbow, long digit heights, above datum, and foot lengths were at par ($p>0.05$) across the three local areas.

When the observed mean differences in body segment parameters across the three study areas were considered, no consistent pattern was observed for the occurrence of the study groups within homogeneous subsets; variations in body segment lengths across local government areas did not present a general trend. For example, although mean elbow to shoulder span of subjects within the Egor area was significantly wider than that of subjects from the other areas, Oredo subjects having significantly wider shoulder to elbow spans than IkpobaOkha subjects, shoulder breadth of Egor and Oredosubjects were at par, though significantly wider than shoulders of IkpobaOkha subjects (Tables 1, 2 and 3).For some body segment parameters, subjects in the three local government areas had similar mean segment dimensions (Tables 1-3).For example, mean statures of subjects from the three areas were statistically at par. Body segment–to–stature ratios applicable to subjects within each of the three local areas studied are presented in Tables 4, 5 and 6. The implication is that area specific models are still more suited to satisfactory product and work place design than generalized models which have been shown to vary across people groups. Pooled body segment dimensions for subjects from the three areas are presented in Table 7. Applicable segment–to–stature ratios for adult craftsmen population within the Benin area are presented in Table 8.

When body segment data generated using Winter's model [22] were compared with actual field data from this study, the model generated data were significantly at variance ($p<0.05$) with observed actual mean data for each segment parameter of Benin Craftsmen (Table 9), except for shoulder breadth ($p=0.59$), waist height above datum ($p=0.15$) and foot length ($p=0.11$) which had insignificant differences.For design purposes, lengths of body segments are often obtained through direct measurement, otherwise generalized models such as Winter's [22] are adopted for estimations based on obtained statures or heights of the target group.Results from this study show that a generalized model specific to craftsmen of Benin origin (Table 8) is more suited for use in design of equipment and workspaces for this target group than the generalized human model given by Winter [22].

Differences in mean body masses of subjects from the three areas was observed to be highly significant ($p<0.032$).

4. RECOMMENDATIONS

For the three local government areas, using mean body segment lengths and masses will not cater for users in the 5th percentile, particularly in the areas of 'reach'. However, such values will do for most of the people in the user group. Where it is possible to incorporate adjustable components in the design of such equipment or workspaces, the lower limits would normally be targeted at users in the 5th percentile while the upper limits should target users in the 95th percentile (Tables 1-3).

Table 4: Ratios of body segment lengths to subject height for mechanics from Egor L.G.A.

s/n	Parameter	MIN	MAX	MEAN	SD
1	Foot Breadth	0.038	0.064	0.051	0.006
2	Ankle Height	0.036	0.076	0.05	0.01
3	Knee Height	0.235	0.375	0.292	0.026
4	Pelvic Height	0.522	0.698	0.589	0.038
5	Chest Height	0.631	0.943	0.761	0.058
6	Hip Breadth	0.171	0.274	0.211	0.025
7	Crown	0.186	0.603	0.507	0.056
8	Trunk Breadth	0.156	0.442	0.191	0.038
9	Shoulder Breadth	0.203	0.338	0.268	0.029
10	Neck to Shoulder	0.078	0.214	0.105	0.02
11	Shoulder to Elbow	0.161	0.279	0.213	0.019
12	Elbow to Wrist	0.126	0.234	0.175	0.023
13	Wrist to Digit	0.07	0.163	0.122	0.014
14	Head Length	0.092	0.178	0.122	0.017
15	Subject Height	1.00	1.00	1.00	0.000
16	Eyes Height	0.836	0.977	0.915	0.029
17	Chin Height	0.641	1.138	0.852	0.058
18	Shoulder Height	0.68	1.001	0.775	0.059
19	Elbow Height	0.582	0.754	0.641	0.041
20	Wrist Height	0.422	0.678	0.503	0.067
21	Long Digit Height	0.121	0.589	0.404	0.083
22	Foot Length	0.136	0.18	0.154	0.01
23	Palm Breadth	0.04	0.07	0.056	0.007

All heights are heights above datum. Datum is the foot platform for the standing subject.

Table 5: Ratios of body segment lengths to subject height for mechanics from Oredo L.G.A.

s/n	Parameter	MIN	MAX	MEAN	SD
1	Foot Breadth	0.04	0.064	0.052	0.005
2	Ankle Height	0.036	0.072	0.046	0.007
3	Knee Height	0.243	0.354	0.29	0.02
4	Pelvic Height	0.51	0.71	0.581	0.041
5	Chest Height	0.647	0.957	0.746	0.055
6	Hip Breadth	0.158	0.467	0.198	0.042
7	Crown	0.047	0.607	0.479	0.078
8	Trunk Breadth	0.128	0.79	0.192	0.083
9	Shoulder Breadth	0.00	0.326	0.256	0.049
10	Neck to Shoulder	0.085	0.158	0.111	0.014
11	Shoulder to Elbow	0.136	0.244	0.198	0.026
12	Elbow to Wrist	0.135	0.24	0.167	0.02
13	Wrist to Digit	0.09	0.155	0.118	0.012

s/n	Parameter	MIN	MAX	MEAN	SD
14	Head Length	0.08	0.162	0.121	0.017
15	Subject Height	1.00	1.00	1.00	0.000
16	Eyes Height	0.851	0.98	0.925	0.024
17	Chin Height	0.648	1.159	0.849	0.063
18	Shoulder Height	0.693	1.014	0.793	0.051
19	Elbow Height	0.581	0.874	0.636	0.041
20	Wrist Height	0.186	0.668	0.487	0.063
21	Long Digit Height	0.311	0.588	0.401	0.05
22	Foot Length	0.129	0.196	0.152	0.013
23	Palm Breadth	0.043	0.069	0.055	0.006

All heights are heights above datum. Datum is the foot platform for the standing subject.

Table 6: Ratios of body sement lengths to subject height for mechanics from IkpobaOkha L.G.A.

s/n	Parameter	MIN	MAX	MEAN	SD
1	Foot Breadth	0.039	0.062	0.05	0.005
2	Ankle Height	0.037	0.07	0.047	0.007
3	Knee Height	0.231	0.372	0.285	0.027
4	Pelvic Height	0.507	0.695	0.583	0.044
5	Chest Height	0.637	0.94	0.752	0.062
6	Hip Breadth	0.147	0.231	0.19	0.02
7	Crown	0.401	0.6	0.491	0.039
8	Trunk Breadth	0.157	0.249	0.206	0.021
9	Shoulder Breadth	0.204	0.331	0.246	0.029
10	Neck to Shoulder	0.083	0.138	0.108	0.012
11	Shoulder to Elbow	0.127	0.269	0.19	0.028
12	Elbow to Wrist	0.126	0.234	0.164	0.022
13	Wrist to Digit	0.095	0.138	0.114	0.011
14	Head Length	0.086	0.167	0.115	0.018
15	Subject Height	1.00	1.00	1.00	0.000
16	Eyes Height	0.795	0.978	0.914	0.038
17	Chin Height	0.775	1.143	0.853	0.051
18	Shoulder Height	0.678	0.999	0.783	0.058
19	Elbow Height	0.567	0.748	0.638	0.042
20	Wrist Height	0.419	0.648	0.489	0.052
21	Long Digit Height	0.31	0.585	0.403	0.058
22	Foot Length	0.12	0.178	0.147	0.012
23	Palm Breadth	0.037	0.074	0.052	0.007

All heights are heights above datum. Datum is the foot platform for the standing subject.

Table 7: Mean body mass and segment lengths for mechanic subjects from Benin City, Nigeria

s/n	Parameter	MIN	MAX	MEAN	SD	PERCENTILES	
						5TH	95TH
1	Foot Breadth	7.10	13.2	9.19	0.95	7.9	11.01
2	Ankle Height	6.80	11.5	8.51	1.42	7.1	11.91
3	Knee Height	6.70	13.5	51.76	3.26	46.13	56.3
4	Pelvic Height	38.9	59.2	104.55	4.68	97.6	113.32
5	Chest Height	91.8	119.7	134.72	6.19	125.27	144.31
6	Hip Breadth	104.8	148.3	35.78	5.67	29.8	44.62
7	Crown	28.1	83.6	88.23	10.5	78.2	99.61
8	Trunk Breadth	8.40	107.5	35.12	9.38	28.08	41.11
9	Shoulder Breadth	23.0	136.8	46.25	5.61	37.59	55.11
10	Neck to Shoulder	31.2	57.0	19.31	2.52	16.2	23.2
11	Shoulder to Elbow	13.6	35.4	35.94	4.67	27.79	42.61
12	Elbow to Wrist	21.8	45.0	30.21	3.69	24.5	36.42
13	Wrist to Digit	22.8	41.2	21.14	2.20	17.3	24.41
14	Head Length	12.5	29.7	21.34	2.74	16.9	25.31
15	Subject Height	15.2	26.9	179.48	9.53	162.25	192.32
16	Eyes Height	149.3	194.7	164.67	9.04	145.17	176.56
17	Chin Height	137.8	182.9	152.61	9.78	136.84	166.7
18	Shoulder Height	115.2	174.2	140.28	7.58	130.59	154.27
19	Elbow Height	113.3	162.4	114.38	6.54	102.6	126.11
20	Wrist Height	93.8	135.2	88.18	9.09	78.37	105.8
21	Long Digit Height	32.9	112.8	72.01	10.29	59.77	88.78
22	Foot Length	21.2	98.4	27.03	1.75	24.0	29.5
23	Palm Breadth	21.3	253	9.75	1.16	7.90	11.51
24	Subject Body Mass	64.0	106.0	81.86	7.30	70.95	94.0

All heights are heights above datum. Datum is the foot platform for the standing subject.

Table 8: Ratios of body segments to subject height for mechanics in Benin City, Nigeria

s/n	Parameter	MIN	MAX	MEAN	SD
1	Foot Breadth	0.038	0.064	0.051	0.005
2	Ankle Height	0.036	0.076	0.048	0.008
3	Knee Height	0.231	0.375	0.289	0.024
4	Pelvic Height	0.507	0.71	0.584	0.041
5	Chest Height	0.631	0.957	0.753	0.058
6	Hip Breadth	0.147	0.467	0.2	0.032
7	Crown	0.047	0.607	0.492	0.061
8	Trunk Breadth	0.128	0.79	0.196	0.054
9	Shoulder Breadth	0.191	0.338	0.257	0.038
10	Neck to Shoulder	0.078	0.214	0.108	0.016
11	Shoulder to Elbow	0.127	0.279	0.201	0.026
12	Elbow to Wrist	0.126	0.24	0.169	0.022
13	Wrist to Digit	0.07	0.163	0.118	0.013

s/n	Parameter	MIN	MAX	MEAN	SD
14	Head Length	0.08	0.178	0.119	0.018
15	Subject Height	1.00	1.00	1.00	0.000
16	Eyes Height	0.795	0.98	0.918	0.031
17	Chin Height	0.641	1.159	0.852	0.057
18	Shoulder Height	0.678	1.014	0.784	0.056
19	Elbow Height	0.567	0.874	0.638	0.041
20	Wrist Height	0.186	0.678	0.493	0.061
21	Long Digit Height	0.121	0.589	0.403	0.065
22	Foot Length	0.12	0.196	0.151	0.012
23	Palm Breadth	0.037	0.074	0.054	0.007

All heights are heights above datum. Datum is the foot platform for the standing subject.

Table 9: Mean body segment lengths and body surface area generated using Winter's model and comparison statistics for Benin Craftsmen

s/n	Parameter	Segment to Stature Ratio [Winter's Model]	MIN	MAX	MEAN	SD	T Probability
1	Foot Breadth	(0.055H)	8.21	10.71	9.87	0.52	0.00
2	Ankle Height	(0.39H)	5.82	7.59	7.00	0.37	0.00
3	Knee Height	(0.285H)	42.55	55.49	51.15	2.72	0.05
4	Pelvic Height	(0.53H)	79.13	103.19	95.13	5.05	0.00
5	Chest Height	(0.72H)	107.5	140.18	129.23	6.86	0.00
6	Hip Breadth	(0.191H)	28.52	37.19	34.28	1.82	0.00
7	Crown	(0.53H)	77.64	101.24	93.33	4.96	0.00
8	Trunk Breadth	(0.174H)	25.98	33.88	31.23	1.66	0.00
9	Shoulder Breadth	(0.259H)	38.67	50.43	46.49	2.47	0.59
10	Neck to Shoulder	(0.129H)	19.26	25.12	23.15	1.23	0.00
11	Shoulder to Elbow	(0.186H)	27.77	36.21	33.38	1.77	0.00
12	Elbow to Wrist	(0.146H)	21.8	28.43	26.2	1.39	0.00
13	Wrist to Digit	(0.108H)	16.12	21.03	19.38	1.03	0.00
14	Head Length	(0.13H)	19.41	25.31	23.33	1.24	0.00
15	Subject Height	(H)	149.3	194.7	179.48	9.53	0.00
16	Eyes Height	(0.936H)	139.74	182.24	167.99	8.92	0.00
17	Chin Height	(0.87H)	129.89	169.39	156.15	8.29	0.00
18	Shoulder Height	(0.818H)	122.13	159.26	146.82	7.79	0.00
19	Elbow Height	(0.63H)	94.06	122.66	113.07	6.00	0.01
20	Wrist Height	(0.485H)	72.41	94.43	87.05	4.62	0.15
21	Long Digit Height	(0.377H)	56.29	73.4	67.66	3.59	0.00
22	Foot Length	(0.152H)	22.69	29.59	27.28	1.45	0.11
23	Palm Breadth	(NIL)	–	–	–	–	–
24	A_s	$71.84(W^{0.425}H^{7.25})$	2.645×10^{18}	1.898×10^{19}	1.085×10^{19}	3.584×10^{18}	–

A_s = Body Surface Area, cm^2; W = Subject body mass, kg; H = Subject Height or Stature, cm

Pooled segment dimensions in Table 7 are reflective of the Benin City craftsmen user group. The generalized model for craftsmen of Benin origin generated from this study (Table 8) is more appropriate for estimating body segment dimensions suited to design of products and workspaces targeting the user group in the study than Winter's model, as shown in Table 9. T-statistics from these comparisons show that only shoulder breadth, waist height from datum and foot length of craftsmen of Benin origin can be satisfactorily estimated using Winter's model, other parameters cannot be so correctly estimated. As such, the field generated model (Table 8) is more suited to the study population than Winter's model (Table 9).

5. CONCLUSION

Body segment lengths and masses of adult craftsmen within the Benin area of Nigeria were obtained through a field survey using standard techniques, with a view to developing design-relevant anthropometric statistics for the study area. The study involved subjects from the three local areas within Benin. Variations in body segment lengths of Benin craftsmen does not present a general pattern across the three local areas studied. Although it is difficult to establish a representative man for the area, it is possible to accommodate sizably large representative populations in design jobs of interest given the presented statistics; sacrifices will usually be for the populations outside the indicated regions and would normally be dictated by design constraints for specified jobs.

REFERENCES

[1] Krupa, F. (1994). History of Human Factors.Design and Technology papers.Available online at: http://www.translucency.com/frede/humfact.html

[2] Kroemer, K.H.E., S.H. Snook, S.K. Meadows and S. Deutsch (Eds.) (1988). Ergonomic models of Anthropometry, human biomechanics, and operator-equipment interfaces. *Proceedings of a workshop on Integrated Ergonomic modelling*. National Academy Press, Washington.

[3] Chan, B.S.T. (1972). Sex difference in the growth of stature and its component segments of Hong Kong Chinese children.*Zeitschrift fur Morphologie und Anthropologie*, 63(3): 323-340.

[4] Tanner, J.M. (1978). *Foetus into man: physical growth from conception to maturity*. Open Books Publishing, London.

[5] Molnar, S. (1998). Human Variation: Races, Types and Ethnic Groups. Prentice Hall,Upper Saddle River.

[6] Bolstad, G., B. Benum, and A. Rokne (2001). Anthropometry of Norwegian light industry and office workers.*Applied Ergonomics*, 32(3): 239-246.

[7] Wang, M.J., E.M.Y. Wang and Y.C. Lin (2002). The anthropometric database for children and young adults in Taiwan.*Applied Ergonomics*, 33: 583-585.

[8] Mozumdar, A. and S.K. Roy (2004). Method for estimating body weight in persons with lower-limb amputation and its implication for their nutritional assessment.*American Journal of Clinical Nutrition*, 80: 868-875.

[9] Lin, Y.C., M.J. Wang, and E.M. Wang (2004). The comparisons of anthropometric characteristics among four peoples in East Asia.*Applied Ergonomics*, 35: 173-178.

[10] Hyncik, L., V. Novaceka, P. Bl'ahab, O. Chvojkac, and P. Krejc (2007). On scaling of human body models. *Applied and Computational Mechanics*, 1(1): 63-76.

[11] So, R.H.Y.,F.C.Y.Lam and R. Goonetilleke. (1996). Anthropometric data of the Hong Kong Chinese population: a literature review and its application to a seated barbecue site design.

Proceedings of the 4th Pan-Pacific Conference on Occupational Ergonomics. Asia World Plaza Hotel, Taipei, Taiwan. Nov. 11 – 14.

[12] Chandra, A., P. Chandna and S. Deswal (2011). Analysis of Hand Anthropometric Dimensions of Male Industrial Workers of Haryana State. International *Journal of Engineering (IJE)*, 5(3): 242-256.

[13] Alicea, B. (2007). Towards a theory of human intraspecific variation for ergonomics and human modeling. Technical Paper, Digital Human Modeling, #2007-01-2461 Presented at the Conference of the Society for Automotive Engineering (SAE).

[14] Garneau, C.J. and M.B. Parkinson (2007). Including preference in anthropometry-driven models for design. Paper #2007-01-2482, Proceedings of ASME International Design Engineering Technical Conferences.

[15] Kelly, C. (2005). The beauty of fit: proportion and anthropometry in chair design. MIndDes. Thesis. Georgia Institute of Technology, Atlanta.

[16] Jung, M.C., J.M. Haight, J.M. and A. Freivalds (2006). Luggage-pulling task evaluation by kinematics and subjective ratings.*The Journal of S H and E Research* 3(1): 1-34.

[17] Pheasant, S. (1986). Bodyspace: Anthropometry, Ergonomics and Design. London:Taylor and. Francis Ltd.

[18] Australian Safety and Compensation Council (2009). *Sizing up Australia: how* contemporary *is the anthropometric data Australian designers use*. Australian Safety and Compensation Commission, Canberra.

[19] Chan, H. and Y. Jiao (1996). Development of an anthropometric database for Hong Kong Chinese CAD operators.*Journal of Human Ergology* 25(1): 38-43.

[20] Anema, J., B. Cuelenaere, A. Van der Beek, D. Knol, H. de Vet, and W. Van Mechelen (2004). The effectiveness of ergonomic interventions on return-to-work after low back pain; a prospective two year cohort study in six countries on low back pain patients sicklisted for 3–4 months. *Occupational and Environmental Medicine,* 61(4): 289-294.

[21] Creative Research Systems (2009). Sample Size Calculator. Creative Research Systems, Petaluma. www.surveysystem.com/sscalc.htm

[22] Winter, D. A. (2009). Biomechanics and Motor Control of Human Movement. John Wiley & Sons, New York. http://dx.doi.org/10.1002/9780470549148