Development of Anthropometric Database for Paraplegics in Nigeria

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Authors’ contributions

This work was carried out in collaboration between all authors. Author BAT carried out the field works under the supervision of author OAO. The main manuscript text was written and organized by authors OAH and OGS conducted necessary data analysis. All authors discussed the results and substantially contributed to the manuscript.

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ABSTRACT

Aims: The main goal of this research is to develop a fresh anthropometric database for disable population in Nigeria.

Methodology: Adequate survey of anthropometric data of Nigeria paraplegics in South-Western Nigeria was carried out with a 31:19 male-female ratio. Suitable and reliable anthropometers were used to collect data on a well-structured questionnaire. Thirty nine (39) body parts of the paraplegics’ population sample were measured and the analysis of the relevant anthropometric measures was carried out using the SPSS Software.

Results: Results show that there are variations in female and male body parts measurements. Based on the need to accommodate at least 90% of the paraplegic population of Nigeria, this paper...
Proposes facilities/workstation design dimensions for waist circumference (50 cm-84 cm), hip-buttock circumference (41 cm-89 cm), waist depth (15 cm-25 cm) for male paraplegics while for female paraplegics while for male paraplegics are waist circumference (49.6 cm-83.2 cm), hip-buttock circumference (56.76 cm-88.80 cm), waist depth (14.20 cm-24.80 cm) among others.

Conclusion: The information presented from the data analysis will be useful for design engineers in designing equipment, workspace and facilities for Nigeria Paraplegics.

**Keywords:** Paraplegics; anthropometry; spinal cord; Nigeria; equipment; design.

1. INTRODUCTION

Generally, anthropometry is the study of measurement of human dimension, which refers to the measurement of living human individuals for the purposes of understanding human physical variation. Over the centuries, there have been remarkable changes in anthropometric measurements due to geographical, cultural genetic and environmental factors as well as worldwide mingling of races [1]. As reported by few studies, human laterality, gender, age and race/ethnicity were mentioned as contributing factors to anthropometric variability [2,3]. Anthropometry is very helpful in variety of professions which include medical, engineering and a host of other professions that provide services and materials for human use. Anthropometry is known to influence physical user-product interactions, and is vital in assessing the fit, safety, comfort, satisfaction, etc. of users [4,5]. Anthropometry is used as design product guideline for heights, clearance, grips, and reaches of workplace and equipment. Examples are the dimensions of workstations for standing or seated work, production machinery, and hand tools for the workforce including men and women who are tall or short, large or small, strong or weak, as well as those who are physically handicapped or have health conditions that limit their physical capacity [6].

Paraplegia or paralysis of lower extremities is caused mainly by disorders of the spinal cord and the cauda equina. They are classified as traumatic and non-traumatic. Traumatic paraplegia occurs mostly as a result of traffic accidents and falls caused by lateral bending, dislocation, rotation, axial loading, and hyperflexion or hyperextension of the cord. Non-traumatic paraplegia has multiple causes such as cancer, infection, intervertebral disc disease, vertebral injury and spinal cord vascular disease [7,8].

Anthropometry data of Paraplegics is however not common. Attempts had been made in times past to obtain these data and have been discovered to come with several variations. Dimension definitions and measurement techniques vary from study to study and, in many cases, samples were very small. In a previously published review of the anthropometry of people with disabilities [9,10] examined six international studies of people with lower limb disorders and discovered that, for a combined total of 58 body size descriptors measured in the studies, not a single dimension was found in common. The annual reported paralysis of lower extremities as disorders of the spinal cord varies from 2.3 per million in a Canadian study to 83 per million in Alaska. The prevalence among men to women varied from 0.9 in Taiwan to 12.0 in Nigeria with the most frequent cause of the injury been traffic accidents and falls. The largest preponderance of men was found among spinal cord injury in studies from Nigeria with ratio 11 – 12:1 [11,12].

In Africa, measuring human body dimensions was given limited attention. Hence Africa is been challenged with unfit products, machines, equipment e.t.c. Ismaila et al. [13] conducted anthropometric dimensions of pupils in Nigeria primary schools. The results of the study showed that all the anthropometric dimensions of the males differ significantly from those of the females with the exception of the elbow hand grip. Hattingh et al. [14] examined anthropometric and biochemical profiles of black South African women. It was reported that most women had a waist-hip ratio less than 0.8 and that the higher percentage of younger women were overweight than the older ones. Ayodeji et al. [15] conducted study on Nigeria paraplegics describing them as neglected set of people and pointed the need for manufacture of tools and utilities used by Nigeria paraplegics to use anthropometric data related to them. Nigeria paraplegics however presents a class of people who as a result of the society and economy, find themselves mostly neglected. A common sight is to see a lot of them by roadsides and public places soliciting for alms. Mobility aids such as wheelchairs, callipers, crutches, walking frames and other facilities are usually imported from
other countries. It is pertinent to note that these facilities were only manufactured in such countries after a detailed collection and analysis of the anthropometric data of users in such countries. According to Gopal [16], when user of a product is able to interact with it in ways that are comfortable and safe, then the user is considered accommodated by the design of the product. In Nigeria, these imported facilities are mostly not accommodated by the users due to variation in anthropometric sizes. Thus, these facilities may present more harm than good in most cases causing secondary deformities since they might not suit the user’s comfort, safety, efficiency and productivity.

1.1 Causes and Classifications of Paraplegia

Any disease process affecting the pyramidal tract of the spinal cord from the thoracic spine downward may lead to paraplegia. Forms of paraplegia may be spastic and rarer. Spastic results in an increased tone in the affected limbs. Causes range from trauma to myelitis transverse and multiple sclerosis. While rarer is the type which is caused by damage to the nerves supplying the legs. Several bacterial, viral, mycobacterial, fungal and parasitic infections can also lead to paraplegia. Table 1 shows the classification of paraplegics based on medical and physical conditions [17-19].

Table 1. Categories of paraplegia based on physical and medical conditions

| Category | Physical and medical condition |
|----------|-------------------------------|
| 1        | Arthritis                     |
| 2        | Organic nervous disorder      |
| 3        | Cerebral vascular disease     |
| 4        | Bone injuries and/or deformities |
| 5        | Lower limb amputation         |
| 6        | Cerebral palsy                |
| 7        | Traumatic paraplegia          |
| 8        | Respiratory and cardiovascular disease |
| 9        | Obesity, congenital errors, spinal injuries |

(Source: Bradtmiller and Annis, [18])

The spinal column is comprised of 33 bones; these bones are referred to individually as vertebrae. This includes 7 cervical vertebrae in the neck, 12 thoracic vertebrae in the upper back corresponding to each pair of ribs, 5 lumbar vertebrae in the lower back, sacral vertebrae which are fused together to form 1 bone called the sacrum and 4 coccygeal vertebrae that are also fused together to form the coccyx or tailbone. It is reported that any spinal cord injury below the drawn line in Fig. 1 will result in paraplegia [20,21].

![Fig. 1. The human spinal cord](image)

1.2 Disability and Complications in Paraplegia

While some people with paraplegia can walk to a degree, many are dependent on wheelchairs or other supportive measures. Due to the decreased movement and inability to walk, paraplegia may cause numerous medical complications, many of which can be prevented with good nursing care. One engineering approach to help the race of paraplegics is to design ergonomics equipment to enhance their movement from one place to the other and also help in their workstations [22]. However accurate and recent anthropometry data is required to achieve this. Hence the objectives of this paper are to obtain anthropometric measurements of paraplegics in selected parts of Nigeria; develop appropriate anthropometric database that relates to the paraplegic in the region for the purpose of designing to suit their needs; find out if the median values of male subjects are significantly different from the median values of the female counterparts, help designers and manufacturers of paraplegic materials to obtain relevant data which will be useful for medical practitioners.

2. MATERIALS AND METHODS

This study involved an extensive case study design of paraplegics conducted during the period of 2014-2015 at The National Orthopaedic Hospital, in South-West Nigeria. The choice of
this study domain was because of availability of large number of the group of people in the area. At the initial survey, all the anthropometric and clinical findings were recorded from a total of 100 paraplegics. At the end of the 7th month, measurement of subjects’ dimensions which included body measurements, weight, and other physical features, comprised male and female in the ratio of 31:19 were completed. Data from different age groups among the paraplegics as listed in Table 2 were also collected through verbal response of the subjects. Participants’ consents were taken orally because majority of them were not literate. However all potential volunteers agreed to have the procedure performed after they were informed that their participation in the study was voluntary. The purpose of the study and the confidentiality of the information provided were emphasized.

Two extra trained personnel were used to assist in data recording to avoid parallax when taking readings and to aid the participants especially due to their physical conditions. Data were collected by using well-structured questionnaire for parameters such as name, age, physical and health conditions. Observation method was used to obtain the gender parameters. The subjects were then measured both by sitting and standing. Standardized guidelines for anthropometric measurements and recording, as stated by NHANES [23], were adopted. Measurements were recorded to the nearest tenth of a centimeter. Participants were convinced to wear light clothing so as to avoid high deviation from actual body measurements. All measuring instruments were inspected before the commencement of measurement, cleaned with alcohol wipes and were properly placed for accessibility.

Table 2. Age groups and description of sample population

| Age (years) | Description       |
|------------|-------------------|
| 0-6        | Infants           |
| 6-12       | Children          |
| 12-18      | Teenagers         |
| 18-45      | Working age       |
| 45-60      | Medium age        |
| 60 Above   | Old age           |

2.1 Anthropometry Parameters

The parameters measured include: Age, weight, Height, Sitting height, Forward reach, Eye height (sitting), Mid shoulder height, Mid shoulder height, Buttock to knee Length, Knee height (sitting), Buttock to heel length, Head height, Head length, Hand length, Hand, Popliteal height (sitting), Hand breadth at metacarpal, Hand breadth at thumb, Elbow to finger-Tip, Chin to eye height, Maximum body Width, Chest Circumference, Waist Circumference, Shoulder Circumference, Hip (buttock) Circumference, Head breadth, Head Circumference, Neck circumference, Inter papillary Breath, Waist depth, Shoulder breadth, Hip breadth, Forearm to forearm breadth, Eye to top of head length, thickness at metacarpal, Foot length, Ball of foot width, Mid upper arm circumference, Abdominal girth and Mid thigh circumference. Several age groups were measured in the categories listed [24].

2.2 The Tools used Include

2.2.1 Stadiometer

This is made of wood with cm calibrations. It is a long standing rod where subjects are made to stand while the measurement is read.

2.2.2 Tape rule

The tape rule is made of latex material and has calibrations in centimetre. Its flexibility allows it to be used for different measurements. The tape rule has a range of 150 cm.

2.2.3 The weighing scale

The weighing scale has a flat surface on which subjects can stand. The capacity of the scale is 120 Kg. The scale is calibrated in Kilogram.

2.2.4 Wooden venier calliper

This is T-shaped wooden equipment. It is calibrated in cm along the longer arm of the Tee where the readings are read from the calliper.

Others include steel measuring tape, head circumference tape among others. The data collected on the anthropometry measurements were analyzed with SPSS software using nonparametric equivalents of the between-subjects t test – the Mann-Whitney U test. This test allows to determine if the median of a variable for participants in one group is significantly different from the median of that variable for participants in a different group [25]. The 5th, 50th and 95th percentile of the various anthropometry parameters were calculated.
3. RESULTS AND DISCUSSION

Detail of statistical description and percentiles of 31 male paraplegias is shown in Table 3, while Table 4 reported that of the 19 Female counterparts. The anthropometric parameters measured were all in centimeters and the analysis presented in Tables 5 reveal the combined body sizes of paraplegic male and females.

The analysis shows that the mean weight of female (52.87 kg) is 11.4% more than that of the male counterparts which is 47.45 kg. In all other measurements, the mean values of female are higher than that of the male except for Height, Mid shoulder height, Hand breadth at Metacarpal and Ball of foot width. In all these parts, Ball of foot width had the highest percentage of about 4%. Prominent among the parts of body with that of female at least 7% more the male include; Mid Upper arm circumference, Head height, Hip height, Hand thickness and weight. In all, Hand thickness has the highest percentage of 52.3% followed by weight which is about 11.4%.

| Descriptions               | Statistics     | Percentiles |
|----------------------------|----------------|-------------|
|                            | Total | Mean | Median | Mode | 5     | 50   | 95    |
| Age                        | 31    | 26.97 | 24.00  | 18  | 6.20  | 24.00| 57.00|
| Weight                     | 31    | 47.45 | 49.00  | 37  | 19.20 | 49.00| 67.60|
| Height                     | 31    | 147.18| 149.00 | 130 | 116.0 | 149.00| 173.2|
| Sitting height             | 31    | 69.04 | 70.00  | 68  | 55.40 | 70.00| 79.60|
| Forward reach              | 31    | 74.14 | 74.00  | 73  | 57.80 | 74.00| 89.80|
| Maximum body reach         | 31    | 39.71 | 38.00  | 38  | 26.80 | 38.00| 56.20|
| Eye height sitting         | 31    | 61.71 | 63.20  | 66  | 46.60 | 63.20| 71.20|
| Mid shoulder height        | 31    | 52.01 | 52.30  | 49  | 41.00 | 52.30| 61.60|
| Buttock to popliteal       | 31    | 37.08 | 38.00  | 38  | 27.92 | 38.00| 43.20|
| Buttock to knee length     | 31    | 43.10 | 43.00  | 42  | 27.00 | 43.00| 55.90|
| Popliteal height sitting   | 31    | 39.79 | 39.90  | 35  | 29.40 | 39.90| 53.10|
| Knee height sitting        | 31    | 48.66 | 48.50  | 41  | 37.96 | 48.50| 63.40|
| Thigh clearance sitting    | 31    | 9.80  | 9.30   | 9   | 7.16  | 9.30 | 13.00|
| Elbow to finger tip        | 31    | 43.94 | 44.00  | 36  | 34.56 | 44.00| 52.60|
| Chest circumference        | 31    | 79.45 | 80.00  | 90  | 61.00 | 80.00| 101.6|
| Shoulder circumference     | 31    | 91.61 | 90.00  | 100 | 71.32 | 90.00| 117.6|
| Hip Buttock circumference  | 31    | 73.68 | 76.00  | 78  | 56.76 | 76.00| 88.80|
| Head breath                | 31    | 18.20 | 18.20  | 18  | 11.92 | 18.20| 24.60|
| Head circumference         | 31    | 56.30 | 56.00  | 54  | 47.40 | 56.00| 64.20|
| Inter pupillary breadth    | 31    | 9.04  | 9.00   | 9   | 5.00  | 9.00 | 12.52|
| Waist circumference        | 31    | 69.16 | 69.00  | 65  | 49.60 | 69.00| 83.20|
| Waist depth                | 31    | 19.23 | 19.00  | 18  | 14.20 | 19.00| 24.80|
| Buttocks to heel length    | 31    | 88.26 | 94.00  | 99  | 64.80 | 94.00| 103.8|
| Shoulder breadth           | 31    | 37.04 | 36.00  | 34  | 28.20 | 36.00| 44.26|
| Hip breadth                | 31    | 26.86 | 28.00  | 23  | 17.00 | 28.00| 34.40|
| Forearm to forearm breadth | 31    | 39.39 | 40.00  | 34  | 31.30 | 40.00| 48.40|
| Head height                | 31    | 23.01 | 23.70  | 26  | 16.38 | 23.70| 29.00|
| Head length                | 31    | 21.77 | 22.00  | 26  | 16.80 | 22.00| 26.20|
| Eye to top of head length  | 31    | 10.22 | 10.20  | 10  | 6.36  | 10.20| 13.70|
| Chin to eye height         | 31    | 12.46 | 13.50  | 14  | 3.86  | 13.50| 17.00|
| Neck circumference         | 31    | 32.04 | 32.00  | 26  | 20.20 | 32.00| 42.80|
| Hand length                | 31    | 19.08 | 20.00  | 20  | 11.68 | 20.00| 23.58|
| Hand breadth at metacarpal | 31    | 8.95  | 9.10   | 7   | 5.52  | 9.10 | 16.36|
| Hand breadth at thumb      | 31    | 11.11 | 11.30  | 13  | 7.80  | 11.30| 14.36|
| Hand thickness at metacarpal| 31    | 3.10  | 3.00   | 3   | 1.69  | 3.00 | 5.02 |
| Foot length                | 31    | 21.20 | 22.00  | 22  | 13.20 | 22.00| 28.40|
| Ball of foot width         | 31    | 10.02 | 9.20   | 7   | 5.36  | 9.20 | 20.64|
| Mid upper arm circumference| 31    | 24.02 | 25.00  | 27  | 14.40 | 25.00| 32.20|
| Abdominal girth            | 31    | 67.07 | 68.10  | 67.00| 51.22 | 70.75| 85.25|
From Table 5, four (4) out of the total 39 body parts measured representing 10.3% had its values of females dimensions different from that of the corresponding male by 1%. In a similar manner, 3 regions (7.7%) by 9% and above, 13 parts (33.3%) by 4-8% and 19 out of the 39 (48.7%) recorded difference of between 1-3%. Some degree of similarity recorded were found in Forward reach, Buttock To Knee Length, Head circumference and Head length of which the differences of male from female counterparts are less than 1.0 cm.

Fig. 2 is a column chart which compares mean values across the male and female measured means. In more than 89% of the various body parts measured, females mean values are higher than that of their male counterpart. However, in the remaining 11% of the total body region, the mean measured values of male are little more than that of the female.

Table 4. Percentile distribution for female studied paraplegics

| Descriptions                                      | Statistic | Percentiles |
|--------------------------------------------------|-----------|-------------|
|                                                  | Total     | Mean | Median | Mode | 5   | 50  | 95  |
| Age                                              | 19        | 32.16| 31.00  | 8    | 8.00| 31.00| 58.00|
| Weight                                           | 19        | 52.87| 57.50  | 52   | 25.00| 57.50| 66.00|
| Height                                           | 19        | 145.21| 143.00 | 143  | 120.00| 143.00| 168.00|
| Sitting height                                   | 19        | 70.21| 70.00  | 70   | 58.00| 70.00| 80.00|
| Forward reach                                    | 19        | 74.37| 73.00  | 70   | 59.00| 73.00| 90.00|
| Maximum body reach                               | 19        | 41.94| 38.20  | 37   | 33.00| 38.20| 54.00|
| Eye height sitting                               | 19        | 62.69| 63.10  | 62   | 44.00| 63.10| 71.00|
| Mid shoulder height                              | 19        | 51.42| 52.00  | 51   | 28.00| 52.00| 62.00|
| Buttock to popliteal                             | 19        | 38.06| 37.00  | 37   | 32.00| 37.00| 42.00|
| Buttock to knee length                           | 19        | 43.34| 43.00  | 42   | 32.00| 43.00| 56.00|
| Popliteal height sitting                         | 19        | 41.13| 40.00  | 37   | 32.00| 40.00| 53.00|
| Knee height sitting                              | 19        | 49.91| 49.00  | 46   | 42.00| 49.00| 63.00|
| Thigh clearance sitting                          | 19        | 10.13| 10.20  | 12   | 6.80 | 10.20| 12.00|
| Elbow to finger tip                              | 19        | 44.69| 44.00  | 42   | 36.00| 44.00| 54.00|
| Chest circumference                               | 19        | 82.32| 80.00  | 80   | 60.00| 80.00| 102.00|
| Shoulder circumference                            | 19        | 96.17| 99.00  | 99   | 72.80| 99.00| 117.00|
| Hip Buttock circumference                        | 19        | 75.45| 77.00  | 77   | 41.00| 77.00| 89.00|
| Head breath                                      | 19        | 18.78| 18.00  | 18   | 12.00| 18.00| 26.00|
| Head circumference                                | 19        | 56.64| 57.00  | 58   | 48.00| 57.00| 64.00|
| Inter pupillary breadth                          | 19        | 9.32 | 9.00   | 10   | 7.40 | 9.00 | 12.00|
| Waist circumference                               | 19        | 72.84| 75.00  | 75   | 50.00| 75.00| 84.00|
| Waist depth                                      | 19        | 20.22| 20.00  | 18   | 15.00| 20.00| 25.00|
| Buttocks to heel length                          | 19        | 92.16| 96.00  | 92   | 70.00| 96.00| 104.00|
| Shoulder breadth                                 | 19        | 38.44| 39.00  | 40   | 31.00| 39.00| 45.00|
| Hip breadth                                      | 19        | 28.94| 30.20  | 32   | 20.00| 30.20| 34.00|
| Forearm to forearm breadth                       | 19        | 40.43| 40.00  | 40   | 33.80| 40.00| 48.00|
| Head height                                      | 19        | 24.96| 25.00  | 22   | 17.00| 25.00| 39.00|
| Head length                                      | 19        | 21.88| 21.00  | 21   | 16.50| 21.00| 26.60|
| Eye to top of head length                        | 19        | 10.53| 11.50  | 12   | 6.30 | 11.50| 13.00|
| Chin to eye height                               | 19        | 13.08| 13.80  | 14   | 2.80 | 13.80| 19.00|
| Neck circumference                                | 19        | 32.94| 32.00  | 22   | 22.00| 32.00| 43.00|
| Hand length                                      | 19        | 19.96| 21.00  | 21   | 13.10| 21.00| 23.00|
| Hand breadth at metacarpal                       | 19        | 8.84 | 9.00   | 8    | 6.10 | 9.00 | 12.00|
| Hand breadth at thumb                            | 19        | 11.46| 11.80  | 13   | 8.00 | 11.80| 14.20|
| Hand thickness at metacarpal                     | 19        | 4.72 | 3.10   | 3    | 2.20 | 3.10 | 31.00|
| Foot length                                      | 19        | 21.58| 21.00  | 21   | 14.00| 21.00| 28.00|
| Ball of foot width                               | 19        | 9.63 | 8.90   | 9    | 5.20 | 8.90 | 13.00|
| Mid upper arm circumference                      | 19        | 25.95| 27.00  | 28   | 16.10| 27.00| 33.00|
| Abdominal girth                                  | 19        | 70.56| 72.00  | 72   | 52.00| 72.00| 84.00|
However, on the result of test statistics on median differences between female and male subjects, Mann-Whitney U test shows P-value of 0.857 (at P<0.005 significant level). Hence this outcome shows that the median values of male populations are not significantly different from that of the female populations.

Based on the need to accommodate at least 90% of the paraplegic population, this study proposes facilities/workstation design dimensions for waist circumference in the range of 50 cm to 84 cm, hip-buttock circumference between 41 cm and 89 cm, waist depth in the scope of 15 cm to 25 cm, buttock-heel length for 70 cm to 104 cm and hip breadth between 20 cm and 34 cm for female paraplegics. However for male paraplegics, waist circumference (49.6 cm-83.2 cm), hip-buttock circumference (56.76 cm-88.80 cm), waist depth (14.20 cm-24.80 cm), buttock-heel length (64.80 cm-103.80 cm) and hip breadth (17 cm-34.40 cm). The study also submitted, for any facilities/workstation design proposed for both male and female paraplegics, the corresponding values for each body region between the 5th to the 95th percentile dimensions as stated in the Table 5.

Anthropometric sizes for each subject are classified by size and depict as percentiles. The mean values for male and female paraplegics suggest that there exists a remarkable difference in their anthropometric dimensions. It further reveals that the human anthropometry does not necessarily follow a particular pattern. Someone with long legs may not necessarily have long arms and vice versa. Also, an older person may also not necessarily have higher anthropometric values than a younger person. There were also subjects which were found to have unusual anthropometry features. This is probably a case of abnormality. A typical example is found in a 5 year old male whose body sizes were larger than older persons’ anthropometry.

Ergonomics design will exceptionally accommodate the extremes cases as it will be difficult to adapt every user in design. However, anthropometric measurements are a guide for design as against assumptions of normality commonly made by some designers in tool designs. A range of user dimensions, typically from a 5th percentile woman to a 95th percentile man, which will takes care of about 9.5 out of 10 users is usually considered. According to the database, tools and equipment designed based on the data can effectively be utilized by both sex of paraplegics for various body dimensions where values do not vary considerably for male and female. However in the other parts where there are significant variations, there must be considerations in the design for the group of people most especially in height, weight and grip dimensions among others.

![Fig. 2. Descriptions of variations between the male and female measured means values of body parts for 50 paraplegics](image-url)
also applicable to designing for minimum accommodate all or virtually all people. This is value of some design feature should could be considered. Designing fo

mean values which are very close to each other average. In this case, 50th percentile or the designer before deciding to design for the person because someone with short legs m

Since there is no such thing as the average person because someone with short legs may not necessarily have short arms. However, thorough analysis needs to be made by the designer before deciding to design for the average. In this case, 50th percentile or the mean values which are very close to each other could be considered. Designing for maximum population value is appropriate if a given high value of some design feature should accommodate all or virtually all people. This is also applicable to designing for minimum population if a given low value of some design feature should accommodate all or virtually all people. In this type of design, the main raw measurements can be used to obtain the dimensions for individuals needed to be considered. However there are some users among the paraplegics that will find such equipment not comfortable to use and this may lead to secondary injuries. In some equipment design which target is to accommodate all ranges or classes of the population by adjusting their parameters, it is the practice to provide for

Table 5. Percentile distribution for both male and female studied paraplegics

| Descriptions                  | Mean F | Percentiles |
|-------------------------------|--------|-------------|
| Age                           | 50     | 28.94       |
| Weight                        | 50     | 49.5080     |
| Height                        | 50     | 146.434     |
| Sitting...height              | 50     | 69.4840     |
| Forward...reach               | 50     | 74.2280     |
| Maximum...body...reach        | 50     | 40.5580     |
| Eye...height...sitting        | 50     | 62.0840     |
| Mid...shoulder...height       | 50     | 51.7860     |
| Buttock...to...popliteal      | 50     | 37.4560     |
| Buttock...to...knee...length  | 50     | 43.1900     |
| Popliteal...height...sitting  | 50     | 40.3020     |
| Knee...height...sitting       | 50     | 49.1340     |
| Thigh...clearance...sitting   | 50     | 9.9260      |
| Elbow...to...finger...tip     | 50     | 44.2280     |
| Chest...circumference         | 50     | 80.5360     |
| Shoulder...circumference      | 50     | 93.3420     |
| Hip...Buttock...circumference | 50     | 74.3540     |
| Head...breath                 | 50     | 18.4220     |
| Head...circumference          | 50     | 56.4280     |
| Inter...papillary...breadth   | 50     | 9.1460      |
| Waist...circumference         | 50     | 70.5580     |
| Waist...depth                 | 50     | 19.6040     |
| Buttocks...to...heel...length | 50     | 89.7400     |
| Shoulder...breadth            | 50     | 37.5680     |
| Hip...breadth                 | 50     | 27.6520     |
| Forearm...to...forearm...breadth | 50   | 39.7860     |
| Head...height                 | 50     | 23.7480     |
| Head...length                 | 50     | 21.8140     |
| Eye...to...top...of...head...length | 50 | 10.3380 |
| Chin...to...eye...height      | 50     | 12.7000     |
| Neck...circumference          | 50     | 32.3800     |
| Hand...length                 | 50     | 19.4140     |
| Hand...breadth...at...metacarpal | 50  | 8.9100     |
| Hand...breadth...at...thumb   | 50     | 11.2438     |
| Hand...thickness...at...metacarpal | 50 | 3.7170  |
| Foot...length                 | 50     | 21.3440     |
| Ball...of...foot...width      | 50     | 9.8724      |
| Mid...upper...arm...circumference | 50 | 24.7540    |
| Abdominal...girth             | 50     | 67.4740     |
| Mid...thigh...circumference   | 50     | 38.6100     |

Since there is no such thing as the average person because someone with short legs may not necessarily have short arms. However, thorough analysis needs to be made by the designer before deciding to design for the average. In this case, 50th percentile or the mean values which are very close to each other could be considered. Designing for maximum population value is appropriate if a given high value of some design feature should accommodate all or virtually all people. This is also applicable to designing for minimum population if a given low value of some design feature should accommodate all or virtually all people. In this type of design, the main raw measurements can be used to obtain the dimensions for individuals needed to be considered. However there are some users among the paraplegics that will find such equipment not comfortable to use and this may lead to secondary injuries. In some equipment design which target is to accommodate all ranges or classes of the population by adjusting their parameters, it is the practice to provide for
the adjustment range to accommodate from the 5th percentile female to the 95th percentile male. Generally, design for the adjustable range will be the preferred method of equipment design for paraplegics such as will ergonomically fix into the users’ needs without putting undue stress on their body.

Prior to this study, there has been some scarcity of recent anthropometry database for Nigeria paraplegics. Major tools and utilities which were designed and manufactured outside Nigeria may not be accommodated by the group of users. With this present database, the same manufacturer can now redesign by making use of this recent developed anthropometric database. Local manufacturers can also tap into the resource established by the outcome of this study for their design for Nigeria paraplegics.

The proper emphasizes on the purpose of this study and the confidentiality assurance information provided notwithstanding, some subjects declined participation. This limited the selected study populations. Difficulty in measurement of certain anthropometric characteristics, because of their physical state, was another limitation recorded in the course of this study. Some of the immeasurable parameters included standing height and hip circumference (standing). However further survey may be needed to complement the results of this finding, especially in other regions of the Country not covered.

4. CONCLUSION

The anthropometric database which contrasts paraplegics of distinctive ages and professions in the South-western Nigeria had been developed from percentile distribution of measurements generated through the raw data obtained from this study. The study also proposed facilities/workstation design dimensions for various body regions. How recently data were collected is important in the use of anthropometric measurements in ergonomics design. This study presents an up-to-date data as obtainable in the current population in the study areas for use in paraplegias equipment design. The analysis on percentile basis will be easily accessible to designers of utilities, equipment and workspace for the group of people. Medical practitioners will equally find the information useful in rendering their services. It is also hoped that this will take care of the lack of reliable anthropometric database for paraplegic population in the part of the country.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Koirala S, Shah S, Baral PA. Comparative anthropometric study of Mongoloid and Tharu Ethnic Races in Eastern Nepal; 2012. Available: www.webmedcentral.com
2. Hu H, Li Z, Yan J, Wang X, Xia H, Duan J, Zheng L. Anthropometric measurement of the Chinese elderly living in the Beijing area. International Journal of Industrial Ergonomics. 2007;37(4):303–311.
3. Mohammed YA. Anthropometric characteristics of the hand based on laterality and sex among Jordanian. International Journal of Industrial Ergonomics. 2005;35(8):747–754.
4. HFES 300 Committee. Guidelines for Using anthropometric data in product design. Human Factors and Ergonomics Society, Santa Monica, CA; 2004.
5. Strasser H. Ergonomic efforts aiming at compatibility in work design for realizing preventive occupational health and safety. International Journal of Industrial Ergonomics. 1995;16:211-235.
6. Grieve D, Pheasant S. Biomechanics In Singleton WT. (ed.) The body at work. Cambridge, Uk: Cambridge University Press; 1982.
7. Howlitt WP. Paraplegia non traumatic. In: Howlitt W. Neurology in Africa. Bergen, Norway: Bodoni; 2012.
8. Chen Y, Tang Y, Vogel LC, Devivo MJ. Causes of spinal cord injury. Top Spinal Cord Inj Rehabil. 2013;19(1):1-8.
9. Kumar S. Perspectives in rehabilitation ergonomics. Pennsylvania: Taylor and Francis, Inc; 1997.
10. Goswami A, Ganguli S, Chatterjee BB. Anthropometric characteristics of disabled and normal Indian men. Ergonomics. 1987;30(5):817-823.
11. Gosselin RA, Coppotelli C. A follow-up study of patients with spinal cord injury in Sierra Leone. Int Orthop. 2005;29:330.
12. Solagberu BA. Spinal cord injuries in Ilorin, Nigeria West. Afr J Med. 2002;21:230-2.
13. Ismaila SO, Akanbi OG, Oderinu SO. Anthropometric and biochemical profiles of black South African women. African Journal of Biomedical Research. 2008;11(2).
14. Hattingh Z, Walsh CN, Veldman FJ, Bester CJ, Ogunibieju OO. Anthropometric and biochemical profiles of black South African women. African Journal of Biomedical Research. 2008;11(2).
15. Ayodeji PS, Adejuyigbe BS, Abiola-Ogedengbe KA. Anthropometry survey and appraisal of furniture for Nigerian primary school pupils. e-Journal of Science & Technology. 2010; 4(5):29-36.
16. Gopal N. Anthropometry-Based sustainable design for multiple global populations The Pennsylvania State University, The Graduate School, College of Engineering; 2012.
17. Hess CW. Non-traumatic acute transverse spinal cord syndromes. Praxis. 2005; 94(30):1151.
18. Bradtmiller B, Annis J. Anthropometry for persons with disabilities: Needs for the 21st Century prepared for U.S. Architectural and Transportation Barriers compliance board under contract no. qa96001001; 1997.
19. Available: http://www.accessboard.org/ research/anthropometry
20. Apparelyzed. The vertebral column and vertebrae. Spinal Cord injury peer support. The UK spinal unit reunion forum; 2005. Available: www.apparelyzed.com/spinalcord-research.html
21. Rehab T. Functional outcomes: Thoracic, lumbar and sacral injuries-paraplegia. The Louis Calder Memorial Library of the University of Miami; 1998. Available: www.calder.med.miami.edu/providers/MEDICINE
22. Solomon L, Nayagam S. Injuries of the spine. In: Solomon l. Warwic DJ, Nayagam S. editor. Apley's system of orthopedics and fractures. 8th ed. London, Hodder Arnold. 2001;27:1-12
23. National Health and Nutrition Examination Survey (NHANES). Anthropometry procedures manual; 2007. Available: www.cdc.gov
24. Edward S, James L, Victor P. The Anthropometrics of disability. Rehabilitation engineering research center on universal design. School of Architecture and Planning, University at Buffalo. The State University of New York. Buffalo, NY 14214-3087; 2002.
25. DeCoster J. Testing group Di®erences using T-tests, ANOVA, and nonparametric measures; 2006. Available: http://www.stat-help.com/notes.html

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