COMPARATIVE ANALYSIS OF MALE AND FEMALE ADULT FOOT DEMOGRAPHIC DATA IN NIGERIA

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ABSTRACT: Anthropometric measurements form the bedrock for the design of products for consumers’ use, therefore, accurate knowledge of the different dimensions and the methods of measurements are key to obtaining veritable data. The evolving nature of the population has made it imperative for a regular up - to - date foot demographic data to be developed and established. As there is paucity of such data, this study seeks to cover this gaping hole. This study adopted the traditional measurement method which entailed the use of anthropometric instruments by five (5) researchers to manually take body measurements of four hundred (400) adult subjects comprising 200 male and 200 female. The participants were within the age bracket of 18-55 years from University of Benin, Benin-City excluding the foreigners, pregnant women, children and individuals with musculoskeletal disorders (MSDS). Stratified random sampling technique was employed in selecting the subjects to be measured. Twenty-seven foot anthropometric data were taken excluding age and weight. The resulting data were descriptively analyzed using SPSS version 16 and paired sample t-test. Result of the descriptive statistics gave the mean age, weight and height of the pooled sample of the population as; 26.47 ± 7.65 years, 63.40 ± 14.07kg and 170.52 ± 8.82cm respectively. The result also revealed that stature is significantly higher in males than in females. The results of the t-test showed that foot length and foot breadth of males differ significantly from those of the females (16.785 and P<0.001), (20.468 and P<0.001). The implication of this is that the foot demographic data established would aid the design of prosthesis and footwear for better functionality.

Keywords: Demographic data, Foot Anthropometry, Prosthesis, Footwear, Descriptive statistics

1. INTRODUCTION

Data on modelling foot anthropometric dimensions for the design of prosthesis and footwear in Nigeria are rare. This situation has therefore established a yawning crevasse for the development of foot anthropometry that can serve as baseline for the design of prosthesis and footwear. Foot anthropometry has shown that foot dimensions vary widely with individuals and the import is that the design of foot wears including prosthesis must consider those variations in order to achieve the desired fitness. The need to also understand the biomechanics associated with the normal foot before any foot orthosis or surgical intervention can be applied is considered necessary. It is instructive to note that prosthesis in this context is referred to as an artificially made limb or part of the body that is used to replace a part of the body that is missing either due to amputation or lack of development while an orthosis is a device used to correct, accommodate, or enhance the use of a body part. However, this study is only concerned with prosthesis. Research interest in Foot anthropometry dates back to the 20th century. Seminal works on foot anthropometry include those by: [1] who examined the postural mechanism of
the human foot. Kondo [2] measured the foot of the students (5-18 years old) in Tokyo using stratified three-stage sampling and found out that foot growth ends in the order of height, breadth and length, that growth of foot stops sooner than stature. Foot measurement for shoe construction with reference to the relationship between foot length, foot breadth and ball girth was carried out by [3]. His study compared the ratios of ball girth/foot length and foot breadth/foot length between the Japanese male subjects and the French male. Wunderlich and Cavanagh [4] analyzed gender differences in foot shape in a large sample of young individuals. Univariate t-tests and multivariate discriminant analyses were employed in assessing the reliability of classification into gender classes, the significant difference between men and women for each foot and leg dimension. Their results showed that for a given stature, men have longer and broader feet than women. They differ at the first toe, lateral side of the foot, the arch and the ball of the foot. They also opined that during the manufacture of women’s sport shoes, these differences should be taken into consideration. Also, [5] quantified the change in three dimensional foot shape under different weight-bearing conditions. An optical digitizing system was used to capture the 3-D plantar surface shape of the foot cast, measurements and comparisons were made. The result indicated that the contact area of the foot increased as the weight bearing increased. Likewise, rear foot width, foot length, foot breadth (width) increased while the arch angle, arch height and average height decreased. Ozden et al. [6] conducted a study on stature and sex estimate using foot and shoe dimensions. Xiong et al. [7] modeled foot dimensions so that the characteristic shape of feet, essentially the region of the mid foot can be understood. They noted that the lack of generalized models has been the cause of the difficulty in the application of foot anthropometry to design good fitting footwear. Fifty (50) Hong Kong Chinese adults comprising 24 females and 26 males took part in the study. The results from the application of mathematical models on the various measurements made, showed that foot height showed no direct relationship with foot length. This result is helpful in designing footwear that has an enhanced fit in the height dimension. Kanaani et al. [8] obtained 8 important foot dimensions and established that there is significant correlation between 85% of foot dimensions. The foot images were taken by a digital camera. A fit size to shoe design was developed by [9]. They selected 303 subjects randomly, in Malaysia for the research and it was revealed that there was a significant difference between the length of the right and left foot. Also, the width of the right and left foot also showed significant difference. Salles and Gye [10] also conducted a study on personalized footwear which can be advantageous for population growth including older individuals, people with arthritis or diabetic foot problems. Personalized footwear can potentially provide a perfect fit for the wearer. Previous studies that also focused on foot measurements include [11-12]. On the area of gender differences, Hong et al. [13] concluded that women showed significantly smaller values of foot dimensions in girth, width and height than men. A total of nineteen foot variables were obtained through video filming, including, width, girth, height, length and angle variables. Also, de Castro et al. [14] identified differences between the anthropometric foot variables of older women and men. They concluded that there were differences between some of the anthropometric foot variables of older women and men that must be considered during their footwear design/manufacture. Samaila et al. [15] measured the anthropometric parameters of foot of adult males and females Ga’anda people, in order to find out racial characteristics of their own, determine their difference and to classify their foot shapes. Abdurrahman et al. [16] described foot anthropometric data of high school students in Bandung for the purpose of manufacturing good fitting shoes. Other studies namely, [17-19] focused on: Foot dimensions of a young adult Nigerian, Enugu Campus within the age bracket of 20-28 years; Sexual dimorphism in foot dimensions among adult Nigerians their age ranged between 18 years and above, resident in Port Harcourt; foot anthropometry of the Igbo people in Nigeria aged 16-45 years respectively. It is evident from the foregoing that there is a balance of literature especially in the area of
assessment of baseline foot demographic data for Nigerian adult Population. Previous studies focused attention more on the estimation of stature (height), prediction of footwear fit, as well as gender (sex), from foot dimensions/measurements. The aim of this research therefore is to develop a robust, up to date male and female demographic data in Nigeria that can help bridge the gap caused by demographic differences and serve as baseline for the design of prosthesis and footwear.

2. MATERIALS AND METHODS

2.1. Materials

The different anthropometric dimensions were obtained with the following anthropometric tools; A-226 standiometer, small height rod, adjustable rule, sliding caliper, soft metric tape. The weight was in kilogram (kg) while the length, breadth and height dimensions were in centimeters (cm). The data for the study were sourced from University of Benin, Benin-City, Edo State. The University of Benin is well situated and has a good quota sample of the parent population. Twenty – seven (27) foot anthropometric dimensions were obtained excluding age and weight. These measurements were from a total of 400 male and female subjects. Below is the list of the dimensions: Age, Weight, Stature (height), Waist height, Waist thigh length, Thigh girth, Crotch height, Knee height, Knee girth, Calf height, Calf girth, lateral malleolus, medial malleolus, Ankle girth, Foot length, Foot breadth, Heel height, Heel girth, Bimalleolar breadth (BMB), Heel breadth, Joint/ball girth, Foot waist girth, Instep girth, Instep height, Instep length, Ball height, Toe length, Toe height, Toe girth.

2.2. Methods

A total of four hundred (400) adult subjects were measured which included 200 male and 200 female by five (5) notable researchers who are well trained in the field of anthropometry. A pilot study was first conducted where each body dimensions was measured 3 times and the average taken before the final measurement of the region was made. The participants were within the age bracket of 18-55 years and from the University of Benin, Benin-City, Nigeria. Stratified random sampling technique was employed in selecting the subjects to be measured. The following groups of people were excluded from the study: Foreigners, Pregnant Women, Children, Individuals with musculoskeletal disorders (MSDS) and Subjects below 18 and above 55 years. The measurements were done by using standard anthropometric instruments and techniques. The descriptive statistics of the resulting data were analyzed using SPSS version 16. The subjects were required to take off their shoes and stockings. They also showed willingness to partake in the study by consenting to be measured in order to obtain the desired data. The measurements were taken at specific period of the day from 9:00am to 3:00pm to avoid diurnal error. Some of the individual foot diagrams are depicted in Figure 1.
3. RESULTS AND DISCUSSION

The characteristics of the subjects concerning demographic data are presented in Tables 1, 2 and 3. In addition, paired sample t-test was employed to compare the variables between male and female variables as shown in Table 4.
### Table 1. Descriptive statistics of females Adult Population.

| MEASUREMENTS (Female) | MEAN  | SD    | MIN  | MAX  | 5th  | 25th | 50th | 75th | 95th |
|-----------------------|-------|-------|------|------|------|------|------|------|------|
| Age                   | 24.74 | 7.43  | 18   | 55   | 18   | 20   | 23   | 27   | 44.9 |
| Weight                | 58.15 | 13.29 | 27   | 120  | 42.05| 49   | 56   | 64   | 79.95|
| Stature               | 164.59| 6.34  | 150  | 182  | 154.5| 160  | 164  | 168.2| 176.74|
| Waist Height          | 103.89| 5.1   | 94.2 | 119  | 97   | 100  | 104  | 107.22| 112.4|
| Waist Thigh Length    | 25.35 | 3.79  | 17   | 38   | 20   | 22   | 25   | 28   | 32   |
| Thigh Girth           | 56.66 | 7.8   | 42.5 | 92   | 46.05| 51.5 | 55   | 61   | 71   |
| Crotch Height         | 77.09 | 4.66  | 65.5 | 88.5 | 70.5 | 73.25| 77   | 79.5 | 85.5 |
| Knee Height           | 48.44 | 3.2   | 35.5 | 59.9 | 44.5 | 46.6 | 48.5 | 50   | 52.5 |
| Knee Circumference    | 38.06 | 4.11  | 24.5 | 55   | 32.52| 35.12| 38   | 40.5 | 45.47|
| Calf Height           | 34.85 | 2.89  | 29   | 43   | 30.02| 33   | 34.55| 36.47| 40.5 |
| Calf Circumference    | 35.13 | 3.54  | 26   | 48.5 | 30   | 32.5 | 35   | 37.5 | 40.95|
| Lateral malleolus     | 6.78  | 0.66  | 5.5  | 8    | 5.8  | 6.22 | 6.9  | 7.3  | 8    |
| Medial malleolus      | 7.78  | 0.72  | 6.4  | 9.4  | 6.5  | 7.2  | 7.8  | 8.2  | 9    |
| Ankle Circumference   | 26.42 | 2.31  | 21.5 | 36.5 | 23.5 | 25   | 26   | 27.5 | 29.97|
| Foot Length           | 24.71 | 1.24  | 21.54| 28.39| 22.7 | 23.09| 24.88| 25.5 | 27.24|
| Foot Breadth          | 9.29  | 0.6   | 7.76 | 10.86| 8.17 | 8.99 | 9.26 | 9.72 | 10.26|
| Heel Height           | 5.23  | 0.74  | 3.5  | 7.4  | 4    | 4.8  | 5.25 | 5.7  | 6.4  |
| Heel Circumference    | 33.19 | 1.84  | 28   | 38   | 30   | 32.5 | 33   | 34.5 | 36.19|
| Bimalleolar Breadth (BMB) | 6.48 | 0.42  | 5.36 | 7.67 | 5.73 | 6.2  | 6.49 | 6.76 | 7.24 |
| Heel Breadth          | 5.57  | 0.53  | 4.15 | 6.91 | 4.61 | 5.24 | 5.61 | 5.86 | 6.5  |
| Joint/Ball Girth      | 23.07 | 1.36  | 19.7 | 27   | 20.8 | 22.22| 23   | 23.7 | 25.49|
| Foot Waist Girth      | 22.77 | 1.43  | 19.3 | 27   | 20.5 | 21.85| 22.85| 23.5 | 25.8 |
| Instep Girth          | 24.01 | 1.55  | 19.5 | 28.5 | 21.5 | 23   | 24   | 25   | 26.5 |
| Instep Height         | 4.17  | 0.55  | 2.5  | 5.8  | 3.3  | 3.8  | 4.2  | 4.5  | 5    |
| Instep Length         | 18.67 | 1.1   | 16.5 | 22   | 17   | 18   | 18.5 | 19.3 | 20.5 |
| Ball Height           | 3.11  | 0.37  | 2.2  | 4.2  | 2.6  | 2.9  | 3    | 3.4  | 3.89 |
| Toe Length            | 7.01  | 0.56  | 6    | 9    | 6.2  | 6.5  | 7    | 7.3  | 8    |
| Toe Height            | 1.92  | 0.22  | 1.5  | 3    | 1.6  | 1.8  | 2    | 2    | 2.3  |
| Toe Girth             | 8.51  | 0.61  | 7    | 10.5 | 7.5  | 8    | 8.5  | 9    | 9.4  |
Table 2. Descriptive statistics of pooled sample (both genders together).

| MEASUREMENTS       | N  | MEAN    | SD      | MIN   | MAX    | 5th    | 25th   | 50th   | 75th   | 95th   |
|---------------------|----|---------|---------|-------|--------|--------|--------|--------|--------|--------|
| Age                 | 400| 26.47   | 7.6492  | 18    | 55     | 18.0   | 21.0   | 25.0   | 29.0   | 43.0   |
| Weight              | 400| 63.4025 | 14.070  | 4     | 27     | 138    | 45.0   | 54.25  | 62.0   | 71.0   | 89.0   |
| Stature             | 400| 170.518 | 8.8246  | 150   | 193    | 157.0  | 163.85 | 169.5  | 177.0  | 185.0  |
| Waist Height        | 400| 106.560 | 5.8236  | 3     | 94.2   | 122.5  | 97.5   | 102.325| 106.0  | 110.0  | 117.975|
| Waist Thigh Length  | 400| 28.4987 | 4.7432  | 2     | 17     | 40     | 21.0   | 25.0   | 28.5   | 32.0   | 36.0   |
| Thigh Girth         | 400| 55.8212 | 6.782   | 2     | 42.5   | 92     | 46.5   | 51.5   | 55.0   | 60.0   | 69.0   |
| Crotch Height       | 400| 76.48   | 4.8087  | 9     | 65.5   | 89.5   | 69.025 | 72.92  | 76.35  | 79.475 | 85.475 |
| Knee Height         | 400| 49.85   | 3.4242  | 2     | 35.5   | 60     | 44.52  | 47.5   | 50.0   | 52.0   | 55.5   |
| Knee Circumference  | 400| 37.7635 | 3.5302  | 9     | 24.5   | 55     | 33.0   | 35.0   | 37.0   | 40.0   | 44.0   |
| Calf Height         | 400| 35.3637 | 3.0285  | 1     | 29     | 44.5   | 30.51  | 33.5   | 35.0   | 37.0   | 41.38  |
| Calf Circumference  | 400| 35.47   | 3.3795  | 6     | 23.9   | 48.5   | 30.51  | 33.0   | 35.5   | 37.5   | 40.5   |
| lateral malleolus   | 400| 7.052   | 0.8375  | 5.5   | 10.5   | 5.905  | 6.5    | 7.0    | 7.5    | 8.5    |
| medial malleolus    | 400| 8.129   | 0.8552  | 5     | 6.18   | 11     | 7.0    | 7.5    | 8.0    | 8.675  | 9.5    |
| Ankle Circumference | 400| 27.29   | 2.5052  | 21.5  | 39     | 24.0   | 26.0   | 27.0   | 28.2   | 31.975 |        |
| Foot Length         | 400| 25.8    | 1.7018  | 21.54 | 30.25  | 22.99  | 24.762 | 25.72  | 27.035 | 28.61  |
| Foot Breadth        | 400| 9.8728  | 0.823   | 7.76  | 11.8   | 8.5    | 9.24   | 9.86   | 10.4375| 11.23  |
| Heel Height         | 400| 5.515   | 0.7661  | 1     | 3.5    | 7.5    | 4.0    | 5.0    | 5.5    | 6.0    | 6.8    |
| Heel Circumference  | 400| 34.769  | 2.5145  | 4     | 28     | 44     | 30.5   | 33.0   | 34.5   | 36.5   | 39.0   |
| Bimalleolar Bre�th (BMB) | 400| 6.816   | 0.5800  | 7     | 5.36   | 8.1    | 5.96   | 6.4125 | 6.77   | 7.2575 | 7.74   |
| Heel Breadth        | 400| 5.74    | 0.5761  | 5     | 4.15   | 7.36   | 4.85   | 5.38   | 5.72   | 6.0875 | 6.77   |
| Joint/Ball Girth    | 400| 24.28   | 1.8084  | 1     | 19.7   | 28.2   | 21.2   | 23.0   | 24.2   | 25.5   | 27.2   |
| Foot Waist Girth    | 400| 23.97   | 1.8429  | 6     | 19.3   | 28     | 21.0   | 22.8   | 24.0   | 25.5   | 27.0   |
| Instep Girth        | 400| 25.2625 | 2.021   | 19.5  | 30     | 22.0   | 24.0   | 25.0   | 26.5   | 29.0   |
| Instep Height       | 400| 4.239   | 0.5926  | 7     | 2.5    | 6      | 3.3    | 3.9    | 4.2    | 4.6    | 5.2    |
| Instep Length       | 400| 19.61   | 1.5341  | 1     | 16.5   | 25     | 17.3   | 18.5   | 19.5   | 20.7   | 22.0   |
| Ball Height         | 400| 3.20925 | 0.4284  | 8     | 2.2    | 4.8    | 2.6    | 3.0    | 3.1    | 3.5    | 4.0    |
| Toe Length          | 400| 7.32125 | 0.7118  | 6     | 4.6    | 9.5    | 6.2    | 7.0    | 7.2    | 7.8    | 8.5    |
| Toe Height          | 400| 1.99    | 0.2494  | 9     | 1.5    | 3.3    | 1.7    | 1.8    | 2.0    | 2.0    | 2.5    |
| Toe Girth           | 400| 9.01175 | 0.781   | 7     | 11.2   | 8.0    | 8.5    | 9.0    | 9.5    | 10.295 |

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Table 3. Descriptive statistics of males Adult Population.

| MEASUREMENTS (male) | MEAN | SD  | MIN  | MAX  | 5th | 25th | 50th | 75th | 95th |
|---------------------|------|-----|------|------|-----|------|------|------|------|
| Age                 | 28.19| 7.49| 18   | 55   | 19  | 23   | 26.5 | 30   | 42.95|
| Weight              | 68.65| 12.84| 46   | 138  | 54  | 60   | 65   | 74.75| 90   |
| Stature             | 176.45| 6.72| 159.5| 193  | 166.2| 171.17| 176.2| 180.87| 187.97|
| Waist Height        | 109.22| 5.27| 98   | 122.5| 101 | 105  | 109  | 112.57| 118.6|
| Waist Thigh Length  | 31.64| 3.29| 24   | 40   | 26  | 29.25| 31.25| 34   | 37   |
| Thigh Girth         | 54.98| 5.43| 43   | 70.5 | 46.5| 51.5 | 54.5 | 58.5 | 64   |
| Crotch Height       | 75.88| 4.89| 67   | 89.5 | 68  | 72.27| 75.5 | 79.27| 85   |
| Knee Height         | 51.26| 3.05| 44.3 | 60   | 46.71| 48.62| 51.4 | 53.4 | 56   |
| Knee Circumference  | 37.47| 2.82| 32   | 44.5 | 33.5| 35   | 37   | 39   | 43   |
| Calf Height         | 35.88| 3.08| 29   | 44.5 | 31  | 33.5 | 35.5 | 38.15| 41.4 |
| Calf Circumference  | 35.82| 3.18| 23.9 | 47.5 | 31.5| 33.77| 35.5 | 38   | 40.5 |
| lateral malleolus   | 7.32 | 0.91| 5.6  | 10.5 | 6   | 6.7  | 7    | 8    | 8.99 |
| medial malleolus    | 8.48 | 0.83| 6.18 | 11   | 7   | 8    | 8.5  | 9    | 10   |
| Ankle Circumference | 28.15| 2.4 | 23.4 | 39   | 25  | 26.5 | 28   | 29   | 32   |
| Foot Length         | 26.89| 1.37| 22.99| 30.25| 24.37| 26.1 | 26.89| 27.7 | 29.49|
| Foot Breadth        | 10.45| 0.57| 8.34 | 11.8 | 9.56| 10.09| 10.41| 10.86| 11.42|
| Heel Height         | 5.8  | 0.68| 4    | 7.5  | 4.5 | 5.4  | 5.9  | 6.27 | 7    |
| Heel Circumference  | 36.34| 2.07| 31.5 | 44   | 32.71| 35   | 36.2 | 37.6 | 39.98|
| Bilamellar Breadth (BMB) | 7.15 | 0.52| 5.5  | 8.1  | 6.3 | 6.79 | 7.21 | 7.57 | 7.87 |
| Heel Breadth        | 5.91 | 0.57| 4.26 | 7.36 | 5.11| 5.47 | 5.87 | 6.33 | 6.89 |
| Joint/Ball Girth    | 25.49| 1.33| 22.3 | 28.2 | 23.4| 24.5 | 25.4 | 26.5 | 28   |
| Foot Waist Girth    | 25.18| 1.36| 21.8 | 28   | 23  | 24.1 | 25.1 | 26   | 27.5 |
| Instep Girth        | 26.52| 1.62| 23.1 | 30   | 24  | 25.2 | 26.5 | 28   | 29   |
| Instep Height       | 4.31 | 0.62| 2.6  | 6    | 3.4 | 3.9  | 4.3  | 4.77 | 5.4  |
| Instep Length       | 20.56| 1.3 | 17.8 | 25   | 18.5| 19.5 | 20.5 | 21.3 | 23   |
| Ball Height         | 3.31 | 0.46| 2.2  | 4.8  | 2.7 | 3    | 3.25 | 3.5  | 4    |
| Toe Length          | 7.63 | 0.71| 4.6  | 9.5  | 6.7 | 7.2  | 7.7  | 8    | 8.89 |
| Toe Height          | 2.07 | 0.26| 1.7  | 3.3  | 1.7 | 1.9  | 2    | 2.2  | 2.5  |
| Toe Girth           | 9.51 | 0.59| 8    | 11.2 | 8.5 | 9    | 9.5  | 10   | 10.5 |

Tables 1, 2 and 3 depict the descriptive statistics of foot measurements of the female, pooled and male sample of the population. The mean age was 24.74 ± 7.43 in females, 28.19 ± 7.49 in males and 26.47 ± 7.65 for the pooled sample. The tables also showed the mean weight to be 58.15 ± 13.29, 68.65 ± 12.84 and 63.40 ± 14.07 for the female, male and both genders together respectively. Similarly, the mean stature in female group was 164.59 ± 6.34 while in male group was 176.45 ± 6.72 and for the pooled sample, 170.52 ± 8.82. The results showed that stature is significantly higher in males than in females which coincide with the result obtained by [11]. For the foot dimensions, the mean foot length for the female was 24.71 ± 1.24 while for male was 26.89 ± 1.37, with the foot length larger in males than in females as compared to that
obtained by [8, 15]. In Table 1, the 50th percentile female was 164cm tall and the stature span was 32cm, from the range of 150cm to 182cm. The 50th percentile male was 176.2cm tall. The tallest male was 193cm, while the shortest was 159.5cm, giving a stature difference of 33.5cm. Also, the 50th percentile for both gender, gave 169.5cm, from 150cm to 193cm with a range of 43cm. The weight was 62kg, with a span of 111kg ranging from 27kg to 138kg. Similarly, the age for the 50th percentile was 25years with a span of 37years from 18years to 55years. The 50th percentile female had a body weight of 56kg from 27kg to 120kg and a span of 93kg. Also the male had a weight of 65kg, the distribution of body weight ranged from 46kg to 138kg and a span of 92kg. For the foot measurements, the 50th percentile female had a foot length of 24.88cm, which ranged from 21.54cm to 28.39cm having a span of 6.77cm. Also, a foot length of 26.89cm was recorded for the 50th percentile male with a span of 7.26cm compared to 26.92 ± 0.13 and 27.1 ± 1.3 cm and 25.1 ± 1.1 cm gotten by [17]. For the pooled sample, the foot length had a value of 25.72cm, having a span of 8.71cm ranging from 21.54cm to 30.25cm. The Mean±SD for bimolleolar breadth of the foot 74.47±4.11 obtained by [8] in Iranian men with ages ranging from 18 to 25 differs significantly from 7.15±0.52 obtained in this study in Nigerian Men with ages 18 to 55 years.

Table 4. Comparison of variables between males and females in foot anthropometry

| Paired Differences | Paired Samples Test |
|--------------------|---------------------|
| Age Male - Age Female | Mean 3.45000 | Std. Deviation 10.91942 | Std. Error Mean .77212 | 95% Confidence Interval of the Difference Lower 1.92741 | Upper 4.97259 | t 4.468 | df 199 | Sig. (2-tailed) .000 |
| Weight Male - Weight Female | Mean 1.05050E-1 | Std. Deviation 19.01652 | Std. Error Mean 1.34467 | 95% Confidence Interval of the Difference Lower 3.15663 | Upper 7.812 | t 7.812 | df 199 | Sig. (2-tailed) .000 |
| Stature Male - Stature Female | Mean 1.18620E-1 | Std. Deviation 9.65483 | Std. Error Mean .68270 | 95% Confidence Interval of the Difference Lower 10.51575 | Upper 13.20825 | t 17.375 | df 199 | Sig. (2-tailed) .000 |
| Waist Height Male - Waist Height Female | Mean 5.32850 | Std. Deviation 7.50504 | Std. Error Mean .53069 | 95% Confidence Interval of the Difference Lower 4.28201 | Upper 6.37499 | t 10.041 | df 199 | Sig. (2-tailed) .000 |
| Waist Thigh Lenght Male - Waist Thigh Lenght Female | Mean 6.28750 | Std. Deviation 4.63774 | Std. Error Mean .32794 | 95% Confidence Interval of the Difference Lower 5.64082 | Upper 6.93418 | t 19.173 | df 199 | Sig. (2-tailed) .000 |
| Thigh Girth Male - Thigh Girth Female | Mean -1.68250 | Std. Deviation 9.96764 | Std. Error Mean .70482 | 95% Confidence Interval of the Difference Lower -3.07237 | Upper -.29263 | t -2.387 | df 199 | Sig. (2-tailed) .018 |
| Crotch Height Male - Crotch Height Female | Mean -1.20600 | Std. Deviation 6.68676 | Std. Error Mean .47283 | 95% Confidence Interval of the Difference Lower -2.13839 | Upper -.27361 | t -2.551 | df 199 | Sig. (2-tailed) .012 |
| Knee Height Male - Knee Height Female | Mean 2.82050 | Std. Deviation 4.53277 | Std. Error Mean .32051 | 95% Confidence Interval of the Difference Lower 2.18846 | Upper 3.45254 | t 8.800 | df 199 | Sig. (2-tailed) .000 |
| Knee Circumference Male - Knee Circumference Female | Mean -5.88000 | Std. Deviation 5.16046 | Std. Error Mean .36490 | 95% Confidence Interval of the Difference Lower -1.30757 | Upper .13157 | t -1.611 | df 199 | Sig. (2-tailed) .109 |
| Calf Height Male - Calf Height Female | Mean 1.02950 | Std. Deviation 4.09812 | Std. Error Mean .28978 | 95% Confidence Interval of the Difference Lower .45807 | Upper 1.60093 | t 3.553 | df 199 | Sig. (2-tailed) .000 |
| Pair  | Paired Differences                        | Mean   | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference | T     | df | Sig. (2-tailed) |
|-------|-------------------------------------------|--------|----------------|-----------------|------------------------------------------|-------|----|----------------|
| Pair 1 | Calf Circumference Male - Calf Circumference Female | .68450 | 4.87585        | .34477          | .00462                                    | 1.36438 | 199 | .048           |
| Pair 2 | Lateral malleolus Male - Lateral malleolus Female | .53350 | 1.10118        | .07786          | .37995                                    | 6.8705 | 199 | .000           |
| Pair 3 | Medial malleolus Male – Medial Malleolus Female | .70590 | 1.06472        | .07529          | .55744                                    | 9.376  | 199 | .000           |
| Pair 4 | Ankle Circumference Male – Ankle Circumference Female | 1.7235 | 3.44357        | .24350          | 1.24333                                   | 2.20367 | 199 | .000           |
| Pair 5 | Foot Length Male - Foot Length Female      | 2.1836 | 1.83981        | .13009          | 1.92711                                   | 2.44019 | 199 | .000           |
| Pair 6 | Foot Breadth Male - Foot Breadth Female    | 1.1583 | .80030         | .05659          | 1.04671                                   | 1.26989 | 20.468 | .000           |
| Pair 7 | Heel Height Male - Heel Height Female      | .57300 | .97185         | .06872          | .43749                                    | .70851 | 8.338 | .000           |
| Pair 8 | Heel Circumference Male - Heel Circumference Female | 3.1520 | 2.88825        | .20423          | 2.74927                                   | 3.55473 | 199 | .000           |
| Pair 9 | Bimolleolar Breadth Male - Bimolleolar Breadth Female | .67410 | .66053         | .04671          | .58200                                    | .76620 | 14.433 | .000           |
| Pair 10| Heel Breadth Male - Heel Breadth Female    | .33520 | .78254         | .05533          | .22608                                    | .44432 | 6.058 | .000           |
3.1. Statement of Hypothesis

\( H_0 \): There are no significant differences between the male and female foot anthropometric dimension.

\( H_1 \): There are significant differences between the male and female foot anthropometric dimensions.

3.2. Interpretation of Selected Results

3.2.1. Ankle circumference

Since t-value obtained is 7.078 and falls outside the lower critical value of 1.243 and upper critical value of 2.204, we therefore reject the null hypothesis and infer that there are significant differences between the male and female ankle Circumference.

3.2.2. Heel circumference

Since t-value obtained is 15.434 and is above the lower critical value of 2.749 and higher critical value of 3.555, we therefore reject the null hypothesis and accept the alternate hypothesis that there are significant differences between the male and female heel Circumference.

3.2.3. Foot length

| Pair      | Joint Ball Girth Male - Joint Ball Girth Female | Mean  | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference | Lower  | Upper  | t     | Df  | Sig. (2-tailed) |
|-----------|-------------------------------------------------|-------|----------------|-----------------|------------------------------------------|--------|--------|-------|-----|----------------|
| Pair 1    | Foot Waist Girth Male - Foot Waist Girth Female | 2.40700 | 1.91643        | .13551          | 2.13978                                  | 2.6742 | 17.76  | 199   |     | .000            |
| Pair 2    | Instep Girth Male - Instep Girth Female         | 2.50800 | 2.13095        | .15068          | 2.21086                                  | 2.8051 | 16.64  | 199   |     | .000            |
| Pair 3    | Instep Height Male - Instep Height Female        | .14000  | .85906         | .06074          | .02021                                   | .25979 | 2.305  | 199   |     | .022            |
| Pair 4    | Instep Length Male - Instep Length Female        | 1.89550 | 1.67627        | .11853          | 1.66176                                  | 2.1292 | 15.99  | 199   |     | .000            |
| Pair 5    | Ball Height Male - Ball Height Female            | .19550  | .57627         | .04075          | .11515                                   | .27585 | 4.798  | 199   |     | .000            |
| Pair 6    | Toe Length Male - Toe Length Female              | .62550  | .83009         | .05870          | .50975                                   | .74125 | 10.65  | 199   |     | .000            |
| Pair 7    | Toe Height Male - Toe Height Female              | .14200  | .33240         | .02350          | .09565                                   | .18835 | 6.042  | 199   |     | .000            |
| Pair 8    | Toe Girth Male - Toe Girth Female                | .99850  | .87152         | .06163          | .87698                                   | 1.1200 | 16.20  | 199   |     | .000            |
Since t-value obtained is 16.785 which fall outside the lower critical value of 1.927 and the upper critical value of 2.440, we therefore reject the null hypothesis and accept the alternate hypothesis that there are significant differences between the male and female foot length. Our result showed that foot length in males are significantly higher than that of females, same with the result gotten by [15].

### 3.2.4. Foot breadth

Since the t-value obtained for the foot breadth is 20.468 and this falls outside the two critical values of 1.047 and 1.270, we therefore reject the null hypothesis and conclude that there are significant differences between the male and female foot breadth which also falls within the result obtained by [15, 18].

### 3.2.5. Calf height and calf circumference

Since the t-value obtained for calf height (1.985) and calf circumference (3.553) falls outside the lower critical value of 0.005 and upper critical value of 1.364 for calf height and a lower critical value of 0.458 and upper critical value of 1.601 for calf circumference, we reject the null hypothesis and accept the alternate hypothesis and conclude that there are significant differences between the male and female calf height and calf circumference. This result can be compare to the one obtained by [4] who stated that after normalization of the measurements by foot length, men and women were found to differ significantly in two calf, five ankle, and four foot shape variables.

Arising from the foregoing, results of the t-test showed that there are significant differences between male and female foot anthropometric dimensions, therefore designs of foot wears and prosthesis should be made differently.

Table 5 and 6 shows the abridged body and foot anthropometric dimensions for Male and Female adults in Nigeria from 18 to 55 years.
Table 5. Abridged Body and Foot Anthropometric Dimensions for male

| S/N | SEX | AGE | WEIGHT | STATE OF ORIGIN | STATURE | WAIST HEIGHT | WAIST THIGH LENGTH | THIGH Girth | TOE HEIGHT | TOE GIRTH |
|-----|-----|-----|--------|-----------------|---------|--------------|-------------------|-------------|------------|-----------|
| 1   | M   | 36  | 83     | ANAMBRA         | 179.6   | 111.8        | 35                |             | 2          | 9         |
| 2   | M   | 19  | 69     | DELTA           | 177.6   | 114          | 36.5              | 54          | -          | 2.2       |
| 3   | M   | 30  | 77     | OYO             | 175     | 107          | 32                | 60          | -          | 2.3       |
| 4   | M   | 29  | 71     | ENUGU           | 170     | 107.5        | 34.5              | 55          | -          | 2.3       |
| 5   | M   | 30  | 92     | DELTA           | 193     | 122.5        | 40                | 60          | -          | 2         |
| 6   | M   | 30  | 74     | ANAMBRA         | 171     | 108          | 35                | 58          | -          | 1.8       |
| 7   | M   | 42  | 83     | EDO             | 173     | 108          | 37                | 63          | -          | 3.3       |
| 8   | M   | 39  | 65     | EDO             | 168     | 104          | 36                | 61          | -          | 1.7       |
|     |     |     |        |                 |         |              |                   |             |            |           |
| 198 | M   | 26  | 55     | OYO             | 165     | 103.5        | 28                | 47          | -          | 2         |
| 199 | M   | 29  | 62     | EKITI           | 167     | 106          | 28                | 56          | -          | 2.4       |
| 200 | M   | 24  | 66     | LAGOS           | 162     | 102          | 30                | 60.5        | -          | 2.1       |

Table 6. Abridged Body and Foot Anthropometric Dimensions for Female

| S/N | SEX | AGE | WEIGHT | STATE OF ORIGIN | STATURE | WAIST HEIGHT | WAIST THIGH LENGTH | THIGH Girth | TOE HEIGHT | TOE GIRTH |
|-----|-----|-----|--------|-----------------|---------|--------------|-------------------|-------------|------------|-----------|
| 1   | F   | 25  | 57     | ANAMBRA         | 159.5   | 97.5         | 30.5              | 55          | -          | 2         |
| 2   | F   | 25  | 55     | IMO             | 169.5   | 109.5        | 28                | 53          | -          | 2         |
| 3   | F   | 20  | 40     | DELTA           | 157     | 97           | 22.5              | 47          | -          | 1.8       |
| 4   | F   | 19  | 62     | DELTA           | 166     | 108.6        | 28.5              | 63          | -          | 2         |
| 5   | F   | 28  | 49     | SOKOTO          | 175     | 106.5        | 19                | 47.2        | -          | 1.7       |
| 6   | F   | 19  | 49     | ONDO            | 168.2   | 107.3        | 22                | 47          | -          | 1.9       |
| 7   | F   | 27  | 55     | DELTA           | 157.5   | 98           | 26                | 55          | -          | 1.9       |
| 8   | F   | 20  | 61     | DELTA           | 164.2   | 109          | 32                | 52.5        | -          | 2.1       |
|     |     |     |        |                 |         |              |                   |             |            |           |
| 198 | F   | 25  | 75     | EDO             | 181.5   | 112          | 22                | 62.5        | -          | 3.2       |
| 199 | F   | 22  | 60     | CROSS RIVER     | 167     | 105          | 26                | 63.5        | -          | 3.4       |
| 200 | F   | 20  | 69     | DELTA           | 171.5   | 108          | 25.5              | 62          | -          | 3         |
4. CONCLUSION

This study has been able to identify the basic demographic differences between male and female adult population in Nigeria from the age bracket of 18-55 years. The pooled demographic changes between the male and female population were also analyzed. It is evident from this study that the anthropometric body dimensions for males and females differ significantly which could be attributed to so many factors such as ethnic and genetic compositions, nutrition, age among others. However, such factors should be critically taken into consideration while designing footwear and prosthesis.

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