

ANTHROPOMETRY DIMENSIONS AND PROTECTIVE WEARS FOR FOOT AND HEAD: A CASE STUDY OF SELECTED POLYTECHNIC STUDENTS IN THE SOUTH ZONE OF NIGERIA

S. N. Onuoha¹, M. C. Okafor¹ and O. Oduma²

¹Department of Agricultural and Bio-environmental Engineering Technology,
Auchi Polytechnic, Auchi, P.M.B. 13, Auchi, Edo State, Nigeria.

²Department of Mechanical Engineering, Ministry of Works and Transport,
Abakaliki, Ebonyi State, Nigeria.

E-mail: sollywise2000@yahoo.com; okaformisharck@yahoo.com.

ABSTRACT

Human body compositions change with age and other related factors, and as such the anthropometric dimensions developed from one region may not be appropriate to be used when designing machines and fittings for people living in another region. This study presents the anthropometric data of Nigerian polytechnic students, which helps to develop and modify foot-and-head protective wears suitable for the people of the region. Eight anthropometric data useful for the design of foot-and-head protective were selected and measured from 800(400 male and 400 female) subjects within the age of 18-30 years. Data obtained was analyzed using independent samples T-test by SPSS (version 18.0). The measurements were compared between two genders and among other ethnic populations of the world. The results showed that male were larger in all the mean dimensions and significant difference was only noticed on foot length dimension for both genders at ($p>0.05$). The results also indicate differences among various foot-and-head dimensions while comparing with other ethnic populations of the world. It is recommended that the study should be extended to different tertiary institutions in our country in order to generate design database for efficient production of foot-and-head facilities and fittings for Nigerian polytechnic students.

KEYWORDS: Foot and head, protective wears, male and female, polytechnic students, anthropometric dimensions.

1. INTRODUCTION

Many studies have shown a mismatch between anthropometric dimensions and protective wears produced for foot – and – head in many countries of the world. New materials and design techniques allow for the creation of more sophisticated foot – and – head protective equipment that has the potential for providing significant improvement in protection level. But in order to maximize the advantages offered by these new products, it is essential to have an understanding of the anthropometric variability of the population that must be protected. Hsiao and Halperin (1998) confirmed that inadequate fit of personal protective equipment can expose workers to injury devices which cannot guarantee the health and safety of workers.

Wearing unfitted shoes lead to foot disorders, mental impacts, dexterity and comfort reduction, increasing energy consumption and decreasing the subject efficiency of performing tasks (Simon, 2004). Zhizhong et al. (2007) discovered differences in body dimensions of elderly Chinese and the Japanese. They found out that the elderly Japanese had larger head dimensions and extremities than their Chinese counterparts; whereas there is larger dimension of body trunk for the Chinese elderly compared to Japanese elderly.

At present, helmets and foot wears are playing vital roles on our bodies not only for beautification but also for safety. Few years ago, Nigerian government came up with white elephant project of passing the bill of wearing helmets by bike users into law without considering the anthropometric head measurements of the target users. The law could not be effective because the helmets being used were not produced with the anthropometric head dimensions of the target users. Most times, these helmets cause discomfort, headache and burden to the users. Head contains the brain which is the centre of reasoning and for this

cause; every step should be taken to ensure that head dimensions are included in the design of head protective wears to ensure that exertion of burden is reduced to the barest minimum.

In Nigeria, researches on foot-and-head anthropometry are scanty or virtually non-existence. Millions of workers in Nigeria including students rely on protective equipment to reduce the risk of occupational diseases and injuries on workshops and farms. The ability to achieve proper foot – and – head fittings for Nigerian population is essential for providing adequate protection to workers. Xiao et al. (1998) measured 41 head – and – face dimensions on 393 Chinese adults. From the collected data, they were able to create regression equations to predict head – and – face dimensions from seven basic measurements collected in 1998. Quamra et al. (1980) also generated regression equation for estimation of stature from foot length. The inspection of the equations reveals that for a given foot length, men are predicted to be taller than women, and hence foot length is greater relative to stature in women than in men.

Left and right feet have almost one quarter of the bones in the body making it an integral part of the body. These bones are joined together to form joints which are firmly held together with the layers of 126 muscles and ligaments (Kanaani et al; 2010). When these muscles become overstretched possibly due to the variability in footwear design techniques, might cause repetitive motion injuries that can further weaken the ankles and muscles.

The objectives of this study are to develop foot-and-head anthropometric database for Nigerian polytechnic students for better design, determine the level of statistical significance of mean anthropometric dimensions of male and female Nigerian polytechnic students, and compare the differences in foot – and – head bodily proportions among four ethnic populations of the world.

2. MATERIALS AND METHODS

2.1 Sample

The sampling strata consisted of 800 students of Auchi, Ogwashi-uku, Ozoro and Bori Polytechnics in Edo, Delta and Rivers states which are located in the South South Zone of Nigeria respectively. A group of 100 male and 100 female students within the age range of 18 – 30 years were selected across each of the four polytechnics based on their willingness and readiness to participate in this study.

2.2 Instruments

Traditional anthropometric instruments were used and these included anthropometer, a steel measuring tape, digital venier caliper, caliper and digital height gauge. The anthropometer, calipers and digital height gauge were manufactured by GPM in Switzerland. The tape is manufactured by Lufkin in the United States.

2.3 Anthropometric Variables Considered

Eight anthropometric variables were considered and collected in this study as shown in Fig. 1. The variables selected were related to head, foot, weight and stature of human body. Weight and stature were taken because they form a set of useful basic body descriptors allowing this data set to be compared to others. Accuracy and reliability of the measurements were achieved by undergoing through a specific training with a certified anthropometrics specialist and practice in performing measurements at the pilot study carried out previously.

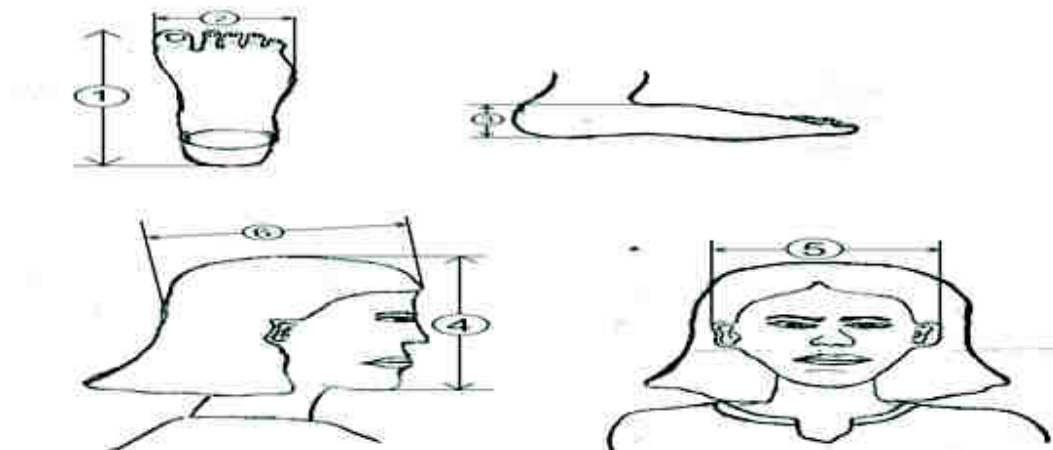


Fig. 1. Selected Anthropometric Variables

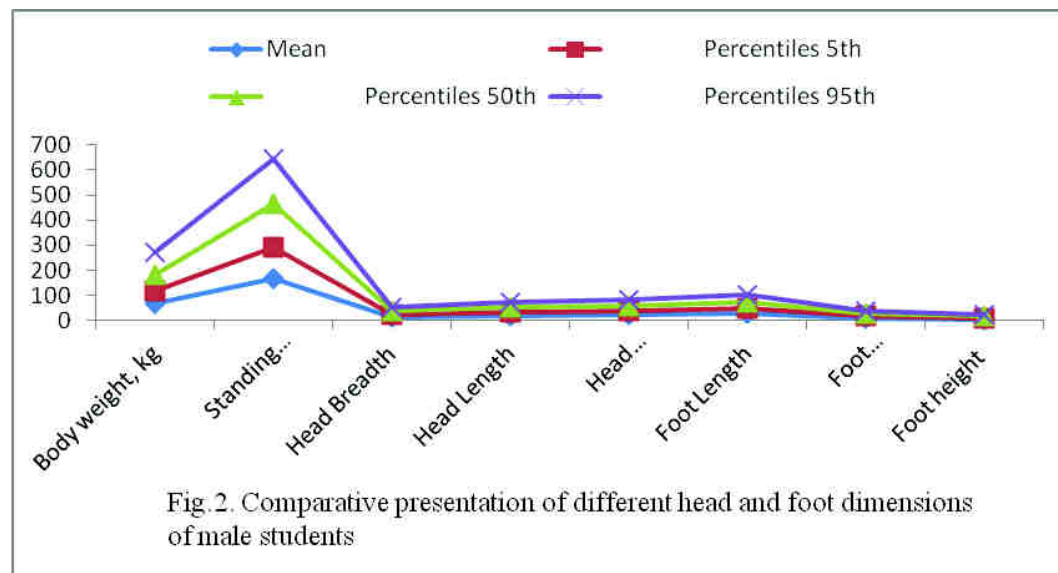
(1) Foot length (2) Foot breadth (3) Foot height (4) Head height (5) Head breadth (6) Head length

2.4 Data Analysis

The data were examined using SPSS analysis to determine the descriptive statistics (mean, standard deviation, standard error of mean, coefficient of variation, minimum, maximum, 5th, 50th and 95th percentiles). The data obtained from male and female students were compared for both genders using simple T-test (2-tailed) at 5% level of significance.

3. RESULTS AND DISCUSSION

The foot-and-head anthropometric variables of 800 Polytechnic students in the South South of Nigeria: 400 males and 400 females are measured and the comparative analysis presented in Fig. 2 and 3 and Tables 1 and 2.



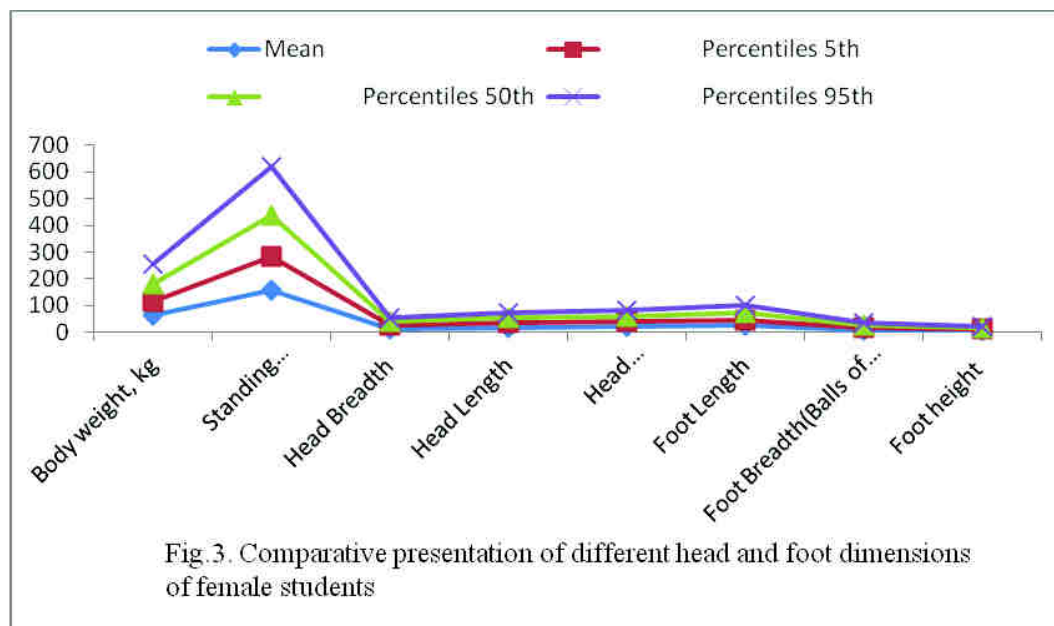


Table 1. Foot and Head Anthropometric Data of Nigerian Male Polytechnic Students

Body Dimension	Mean	Std. Error of Mean	Std. Dev	Min	Max	Percentiles		
						5 th	50 th	95 th
Head Breadth	12.5	0.2	0.8	11.4	14.1	11.4	12.5	14.1
Head Length	17.8	0.3	1.4	15	20.2	15	17.8	20.2
Head Length (maximum)	20.8	0.4	1.7	17.8	23	17.8	20.5	23
Foot Length	25.7	0.4	2.0	21.9	28.5	21.9	25.6	28.5
Foot Breadth (Balls of Foot)	9.1	0.3	1.1	7.6	11.4	7.6	9.0	11.4
Foot height	5.6	0.2	0.4	4.5	5.8	4.5	5.8	5.8

Table 2. Foot and Head Anthropometric Data of Nigerian Female Polytechnic Students

Body Dimension	Mean	Std. Error of Mean	Std. Dev	Min	Max	Percentiles		
						5 th	50 th	95 th
Head Breadth	13.1	0.1	0.7	11.9	14.1	11.9	13	14.1
Head Length	18.2	0.3	1.1	16.7	20.0	16.7	18.4	20
Head Length (maximum)	20.6	0.3	1.5	18.4	23.4	18.4	20.2	23.4
Foot Length	25.1	0.6	2.4	20.3	29.0	20.3	25.4	29
Foot Breadth (Balls of Foot)	8.5	0.2	0.7	6.9	10.0	6.9	8.7	10
Foot height	5.3	0.1	0.4	4.7	5.8	4.7	5.3	5.8

Body dimensions which also included foot - and - head measurements are reported to change due to age, nutritional intake, race, gender among others (Agrawal et al; 2010). To investigate these differences, statistical T – test analysis were used to compare anthropometric variables of male and female gender at 0.05 significance and the results are provided in Table 3.

Table 3: T-Test Analysis of male and female anthropometric data of Nigerian polytechnic students

Body Dimensions	Mean Male	Mean Female	N	Tcal	Df	sig. (2-tailed)	Decision $p > 0.05$
Body Weight(kg)	66.7	62.7	800	1.344	799	0.195	NS
Standing Height(stature)	167.3	157	800	0.84	799	0.42	NS
Head Breadth	13.1	12.5	800	-1.798	799	0.088	NS
Head Length	18.2	17.8	800	-1.143	799	0.267	NS
Head height	20.8	20.6	800	0.432	799	0.671	NS
Foot Length	25.7	25.1	800	-0.901	799	0.379	NS
Foot Breadth (Balls of Foot)	9.1	8.5	800	2.038	799	0.056	S
Foot Height	5.6	4.8	800	1.600	799	0.154	NS

Note: all dimensions in cm except mentioned

The result of T – test analysis for both genders demonstrate differences between males and females foot – and – head dimensions. Male were larger in all the dimensions. Furthermore, significant difference was only noticed between the male and female foot breadth dimensions at ($P > 0.05$). Thus, designers and manufacturers of foot – and – head protective of this population groups should give consideration to data generated when designing any product.

The mean foot length of male and female students were 25.7cm and 25.1cm respectively, which is useful in the design of accelerator pedal, clutch pedal, brake pedal and similar other foot-operated controls. For efficient and effective design of helmets and other related head wears, the mean head breadth of 13.1cm, head length of 18.2cm and head height of 20.6cm for male polytechnic students and mean head breadth of 12.5cm, head length of 17.8cm and head height of 20.8cm for female polytechnic students respectively should be considered.

The comparison of bodily proportion among four ethnic populations of the world is shown in Table 4.

Table 4. Comparison of mean of foot- and- head proportions to the mean stature for present study and other ethnic population of the world

Measurement (cm)	Nigeria (Present study)		Malays (Karmegam, et al; 2011)		Chinese (Karmegam, et al; 2011)		Indians (Karmegam, et al; 2011)	
	Male	Female	Male	Female	Male	Female	Male	Female
Head breadth	0.0834	0.07472	0.0856	0.0982	0.0909	0.0921	0.0882	0.0913
Head length	0.1159	0.1064	0.1020	0.1146	0.1064	0.1117	0.1079	0.1168
Head height	0.1243	0.1312	0.1367	0.1454	0.1448	0.1417	0.1366	0.1389
Foot length	0.1536	0.1599	0.1519	0.1466	0.1497	0.1459	0.1526	0.1497
Foot breadth	0.0544	0.0541	0.0556	0.0553	0.0571	0.0545	0.0571	0.0552

The present study (Nigerian) has the lowest foot breadth, head breadth and head height but the largest foot length. The result also shows that the present study (Nigerian) has largest head length among males and relatively lowest head length among females. More so, the Chinese male has the greatest head breadth followed by Indian males whereas among females, Malays have the largest head breadth followed by Chinese. However, Chinese males have similar foot breadth with Indian males but among females, Malays has the largest foot breadth. The Chinese females generally tend to be smallest in both foot length and head length whereas Indian females have the largest head length among the ethnic populations. Head height of Chinese male was observed to be largest followed by Malays and Indians with close similarities in values. Among females, Malays has the highest values of head height followed by Chinese and Indians; Nigerians (present study) being the least.

The study presents compilation of foot – and – head anthropometric data of male and female selected Polytechnic students in Nigeria that would be used as a guide for designing and modifying of accelerator

pedals, clutch pedals, brake pedals, helmets and foot operated controls and other similar products for foot –and- head protections.

4. CONCLUSIONS AND RECOMMENDATIONS

According to the research findings in this study, the following details were concluded. The comparison of foot-and-head anthropometry between male and female students of Nigerian Polytechnics, could be concluded that male students have highest values in all foot-and-head sizes more than their female counterpart; with only foot breadth been statistically significant at ($P>0.05$).

The characteristics of bodily proportion among the four different ethnic populations of the world for both genders are not similar. Significant differences exist among them. These anthropometric variables can be utilized in the design of foot and head protective, pedal for accelerators, clutch pedals, brake pedals, foot wears, caps and other foot - and – head fittings and facilities. It is recommended that extensive surveys for both male and female students of south south Nigerian Polytechnics be extended to other tertiary institutions of the country in order to generate design database for safe and efficient production of foot wears, foot operated machines, head protection facilities and fittings for Nigerian students.

REFERENCES

- Agrawal, K.N., Singh, R.K.P. and Satapathy, K.K. 2010. Anthropometric Considerations of Farm tools/Machinery design for tribal workers of Northern Indian. *Agric Eng. Int: CIGR Journal*, 12(1): 143 – 150.
- Hsiao, H. and Halperin, W.E. 1998. Occupational Safety and Human factors (<http://www2a.cdc.gov/nioshtic-2/buildQyr.asp?S1=20037099&f1=NN&View=e>). In William N.Rom (Ed.), *Environmental and Occupational Medicine* (pp. 923 -936). Philadelphia: Raven Publishers.
- Kanaani, J.M., Mortazavi, S.B., Khavanin, A., Mirzai, R., Rasolzadeh, Y and Mansurizadeh, M. 2010. Foot Anthropometry of 18 – 25 years Old Iranian male students. *Asian Journal of Scientific Research*, 3: 62 – 69.
- Karmegam, K., Sapuan, S.M., Ismail, N., Shamsul Bahri, M.T., Shuib, S., Mohana, K., Seetha, P., Tamilmoli, P. and Hanapi, M.J. 2011. Anthropometric Study among adults of different ethnicity in Malaysia. *International Journal of Physical Science*, 6(4): 777 – 788.
- Quamra, S. R., Jit, I and Deodhar, S. D. 1980. A model for reconstruction of height from foot measurements in an adult population of North West India. *Indian J Med Res* 71:77–83.
- Simon, H. 2004. What makes a good boot? Extremities Performing Research Group, Department of Design and Technology Louthborough University, <http://www.dtic.mil/ndia/2004:issc/thursday/hodder.ppt>.
- Xiao, H., Hau, D.H., Liu, W et al 1998. A research on head – face dimensions of Chinese adults. The fifth conference of Chinese ergonomics society (ID141187). Pp 8 – 9.
- Zhizhong, L., Haitao, H., Jingbin, Y., Xiaofang, W., Hui, X., Jiyang, D. and Zheng, L. 2007. Anthropometric measurement of the Chinese elderly living in the Beijing area. *International Journal of Industrial Ergonomics*, 37: 303 – 311.