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Ergonomic Implications of Hand Anthropometry and Hand Dominance among Selected Nigerian Male Automotive Workers.

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ABSTRACT
This study examined the relationship between hand anthropometry and hand dominance among selected Nigerians in the automotive industry. A cross-sectional, descriptive study was carried out on 45 male automotive workers between the ages of 30 – 49, in selected automotive workshops located in the city of Port Harcourt. Exclusion criteria were; history of upper limb injuries or disorders. The following parameters were measured from the upper limb; mid-arm circumference, arm length, forearm length, hand length and hand width. Handgrip strength was measured on right and left hands by using a standard adjustable digital hand grip dynamometer (CAMRY EH101), Zhongshan Camry Electronics Ltd, Shinqi, China. Paired t-test and Pearson's correlation were employed. A probability (p)<0.05 was taken to indicate level of statistical significance. Data analysis was carried out with Statistical Package of Social Sciences (SPSS) version 23.0. Dominant handgrip strength (43.18kgf) had a higher average value than non-dominant hand grip strength (36.00kgf). Mid-arm circumference mean was 25.29 ± 3.23cm. Arm and forearm length values were 31.41 ± 1.95cm and 27.51 ± 1.95cm respectively. Hand length and width values were 18.70 ± 1.19cm and 8.71 ± 0.63cm respectively, with hand index (46.60 ± 2.50). Positive correlations were observed between handgrip strength and anthropometric parameters such as arm length (R = 0.34, p = 0.02) and forearm length (R = 0.34, p = 0.02). The application of hand dominance and its anthropometry is essential in the design of occupational equipments especially in the automotive industry for better management and rehabilitation of hand-related injuries.

Keywords: Hand anthropometry, Hand dominance, musculoskeletal injuries, automotive industry.

INTRODUCTION
The upper limb, prehensile in design, is relevant in carrying out various occupational activities, many of which could result in a number of musculoskeletal poblems[1]. Authors have produced evidence to support the argument that a strong relationship exists between between certain occupational factors and clinical conditions of the musculoskeletal system.[2,3] These factors include heavy lifting, vibrations, static work postures and repetitive work tasks.[4-6]

The relationship between human anthropometric dimensions and the design of ergonomic tools or equipment have been studied with regards to ergonomic principles and there is agreement that in resource limited countries there is a trend towards decreased productivity. This study therefore underscores the need for additional anthropometric information specific for Nigerians in the design of tools and equipment that can be added to literature derived database[7,8] Norris and Wilson[9] and Xiao *et al*[10].

Handgrip strength is the highest power of forceful flexion of all fingers under normal bio-kinetic conditions.[11] In terms of the significance of hand anthropometry and biomechanics, it directly impacts a host of biological variables such as age, sex and body size. Handgrip strength is a reliable diagnostic tool in determining the muscular strength of any individual in health and illness.[12,13] Several studies have sought to provide better understanding of the factors that affect handgrip strength with respect to occupational safety and ergonomics.[14-1617-22]

However, there has been little or no related research done in automotive workers in Nigeria.

In an attempt to understand better the relationship between grip strength and handedness, Chatterjee et al.,[23] and Balogun et al., [24] classified their study participants into two main groups; dextralists (right-handed) and sinistralists (left-handed).

The aim of this present study was to evaluate hand anthropometry and hand dominance among selected Nigerian automotive workers.

MATERIALS AND METHODS

This study was cross-sectional and descriptive in design and was carried out after obtaining approval from the research ethics committee of the University of Port Harcourt, Nigeria.

Participants were 45 male automotive workers with a mean age of 30 – 49, working in selected automobile workshops located in the city of Port Harcourt. Informed consent was obtained from these participants prior to the period of data collection. Individuals with deformities trauma and other abnormalities were excluded from the study.

The following measurements were made on the hand

i. **Hand Grip Strength**: Handgrip strength of right and left hands was measured by using a standard adjustable (CAMRY EH101) digital hand grip dynamometer. As recommended by the American Society of Hand Therapists (ASHT), participants were made to sit in an erect position with shoulder adducted and neutrally rotated and elbow flexed at 90^{o} with the forearm in neutral position.[25] They were instructed to squeeze the dynamometer as tightly as possible. The force exerted was later read from the dial of the dynamometer in kilograms and after three successful attempts (with one-minute rest between trials), the average was calculated and recorded.

ii. **Hand Dominance**: Dominant hand is defined as the one which is preferred by any given person for daily activities such as writing, eating, sweeping, cutting grass, throwing a ball, etc.[26]

iii. **Arm and Forearm Length**: The arm length was measured with the forearm flexed on the arm at 90 degrees elbow with the subject in standing position. It is defined as the distance between the acromion end of clavicle and olecranon process.[27] Forearm length was measured from the tip of olecranon process to the point between radius and ulna tuberosity.[28]

iv. **Hand Length and Hand Width**: Measurement of the hand length was taken on dominant hand from the tip of the middle finger to the distal wrist crease. Measurement of hand breadth was also taken in dominant hand from the radial side of index finger to ulnar side of small finger. Hand measurements were obtained using both standard flexible measuring tape and digital Vernier caliper with the hand extended and relaxed while the elbow was supported on a table. Hand index, according to Aboul-Hagag *et al*[29] was calculated mathematically as the hand width divided by hand length and multiplied by 100.

v. **Mid-arm Circumference**: Mid-arm circumference defined as the circumference of the upper arm measured at the midpoint between the tip of the acromion and the tip of the olecranon process.

Statistical Analysis: Data obtained from this study were arranged, organized and presented in tables and scatterplots. Mean and standard deviation were obtained for all measurements. A paired t-test was used to compare the differences between dominant and non-dominant handgrip strength. Pearson's correlation coefficient was used to determine the relationship between handgrip strength and hand anthropometry measurements. A level of probability less than 0.05 was considered to indicate statistical significance. All calculations using the estimators stated above were done with the aid of Statistical Package of Social Sciences (SPSS) version 23.0.

RESULTS

Table 1 shows mean and standard deviation of the dominant and non-dominant handgrip strength in. It was observed that the dominant handgrip strength had a significantly higher mean value (43.18kgf) than that of the non-dominant hand (36.00kgf).

Table 2 shows mean and standard deviation for all the measured anthropometric variables obtained from the automotive workers. Mean values for mid-arm circumference, arm length, forearm length, hand length, hand width and hand index were, 25.29cm, 31.41cm, 27.51cm, 18.70cm, 8.71cm and 46.60, respectively.

Table 3 shows the relationship between handgrip strength and the measured anthropometric parameters using the Pearson's correlation coefficient. At $p \leq 0.05$, there was a statistical significance observed between handgrip strength and anthropometric parameters such as arm length ($R = 0.34$, $p = 0.02$) and forearm length ($R = 0.34$, $p = 0.02$).

Table 1: Descriptive and Inferential Statistics of Hand Grip Strength (HGS)

HAND GRIP STRENGTH (HGS)	NUMBER OF PARTICIPANTS	MEAN	STANDARD DEVIATION	PAIRED T – TEST VALUE	P VALUE
Dominant HGS (kg)	45	43.18	4.11	9.98	0.001
Non-dominant HGS (kg)	45	36.00	4.31		

(Level of Significance at 0.05)

Table 2: Descriptive Statistics of Measured Anthropometric Variables

ANTHROPOMETRIC PARAMETERS	NUMBER OF PARTICIPANTS	MEAN	STANDARD DEVIATION
Mid-arm Circumference (cm)	45	25.29	3.23
Arm Length (cm)	45	31.41	1.95
Forearm Length (cm)	45	27.51	1.95
Hand Length (cm)	45	18.70	1.19
Hand Width (cm)	45	8.71	0.63
Hand Index	45	46.60	2.50

Table 3: Correlation between handgrip strength and anthropometric variables in subjects

STATISTICS	MID-ARM CIRCUMFERENCE	ARM LENGTH	FOREARM LENGTH	HAND LENGTH	HAND WIDTH	HAND INDEX
R	0.05	0.34	0.34	0.25	0.21	0.00
P – VALUE	0.74	0.02*	0.02*	0.10	0.16	0.99

(* signifies level of significance at $p \leq 0.05$)

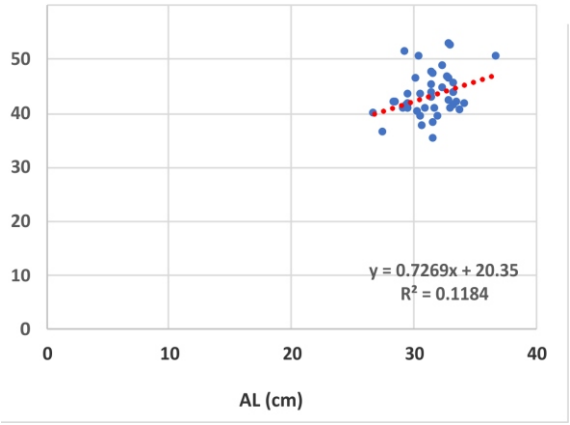

Figure 1: Scatterplot of Correlation between Dominant Handgrip strength and Arm Length (d.HGS = Dominant Handgrip strength, AL = Arm Length)

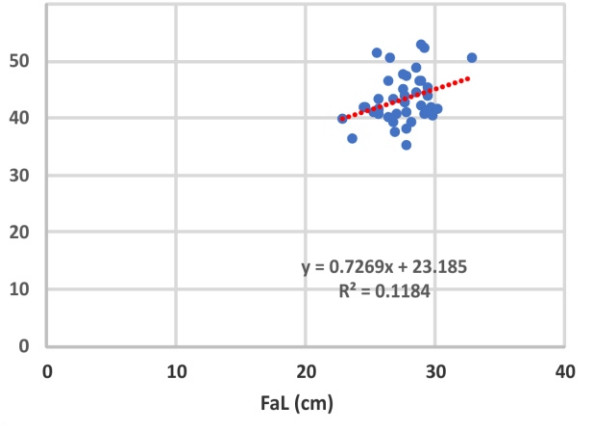

Figure 2: Scatterplot of Correlation between Dominant Handgrip strength and Forearm Length (d.HGS = Dominant Handgrip strength, FaL = Forearm Length)

DISCUSSION

The hand is used in regularly in activities of daily life and for work in Industries and so work related musculoskeletal disorders (MSDs) of the hand are common.[1,30] Hand injuries and other forms of disorders in the hand result frequently result from repetitive motions and awkward postures assumed by people who work in places like automotive industries. Such postures such as stooping, squatting prolonged standing when carried out with tools which are not designed based on ergonomic principles often result in unremarkable or weakened hand grip strength .[31-33] This study attempted to investigate the role of hand dominance and its anthropometry on the ergonomic environment of automotive workers residing in selected automotive workshops located at the city of Port Harcourt, Nigeria.

We observed that in these automotive workers, hand grip strength in the dominant hand was significantly higher than the non-dominant one. The mean and standard deviation values of grip strength for dominant and non-dominant hands were 43.18 ± 4.11 and 36.00 ± 4.31 respectively. Bechtol[34] reported that the dominant handgrip strength is approximately 10% greater than the non-dominant handgrip strength. Our findings are in agreement with that report.

Also, mean and standard deviation values for mid-arm circumference were 25.29 ± 3.23. Arm and forearm length had mean and standard deviation values of 31.41 ± 1.95 and 27.51 ± 1.95 respectively. Khanal *et al*[35] reported similar results.
There were strong positive correlations between handgrip strength and anthropometric parameters such as arm length ($R = 0.34$, $p = 0.02$) and forearm length ($R = 0.34$, $p = 0.02$).

Hand length and hand width had mean and standard deviation values of 18.70 ± 1.19 and 8.71 ± 0.63 respectively while hand index had a mean and standard deviation of 46.60 ± 2.50. These values are in agreement with values observed in previous related studies.[36-39] Values obtained from this present study were lower compared with some related studies done by Mokdad[40], Taha and Nazaruddin[41]and Motamedzade *et al*[42], these differences could be as a result of population and ethnic differences, and the fact that whereas most of the jobs in the automotive industries in Nigeria are floor based.

CONCLUSION

The application of hand dominance and its anthropometry could be essential in the design of occupational equipment especially in the automotive industry for better management and diagnosis of hand-related injuries and disorders. This study showed that among workers in the automotive industry, the arm and forearm length measurements are directly proportional to the dominant handgrip strength measurement. Also, hand length and width measurements generated from this study will be useful in occupational health education, rehabilitation, research and rehabilitation

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Author's Contribution: Both authors contributed significantly to the research work.

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