Sex and Age Variations in Anthropometry and Hand Grip Strength amongst Students of Ahmadu Bello University, Nigeria

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Abstract

Hand grip strength (HGS) is a physiological variable that is affected by several factors including age, gender and body size among others. The power of grip is the result of forceful flexion of all finger joints with the maximum voluntary force that the subject is able to exert under normal biokinetic conditions. This study was designed to determine sexual dimorphism in HGS and anthropometric variables between males and females and the relationship between HGS, age and anthropometric variables in students of Ahmadu Bello University(ABU), Zaria. Participants (n=612) were undergraduate and post graduate students of the Ahmadu Bello University, Zaria, male (n=302) and female (n=310), age range 18 to 45 years. Participants were divided into three age groups of 18-25, 26-35 and 36-45. HGS in standing with elbows in full extension and HGS in sitting with elbows at 90^0 flexion was measured using a baseline hydraulic hand dynamometer. Hand length (HL), hand breadth (HB), forearm length (FAL), arm length (AL) and mid arm circumference (MAC) of participants were measured using appropriate equipment and methods and body mass index (BMI) was calculated. The finding of the study showed significant sexual dimorphism in the anthropometric variables with males showing higher values than females except for BMI. Significant (p<0.05) sexual dimorphism was found in all the studied anthropometric variables, except for AL and MAC. This study also revealed that participants in the age range of 26-35years had remarkably (p<0.05) higher values of grip HGS in both standing and sitting positions; increase in the anthropometric variables of MAC, HT, WT and BMI in relation to the other age categories. This study confirms sexual dimorphism. The study confirms that HGS varies with age.

Keywords: HGS in standing, HGS in sitting, Sexual dimorphism, Anthropometric variables.

INTRODUCTION

Sexual dimorphism, in general, refers to the differences between males and females of the same species in terms of appearance, shape, size, structure and behaviour (Ashok *et al*, 2007). Anthropometry, literally connotes measurement of humans, refers to measurement of living humans for the purpose of understanding human physical variation. Anthropometry plays an important role in industrial design, clothing design, ergonomics, and architecture, where statistical data about the distribution of body dimensions in the population are used to optimize products (Adebisi, 2008).

Hand grip strength (HGS) is a physiological variable that is affected by a number of factors including age, gender and body size among others (Koley *et al*, 2008). The power of grip is the result of forceful flexion of all finger joints with the maximum voluntary force that the subject is able to exert under normal biokinetic conditions (Richards *et al.*, 1996; Bohannon *et al.*, 2006). The assessment of grip strength is used to assess the function of the hand, using a dynamometer (Mark, 2023). There are three main categories of hand grip dynamometer. These include spring-loaded compression, air compression and hydraulic compression devices (Waldo, 1996).

When testing grip strength, there are many variables that need to be normalized before testing. The testing protocols need to be consistent with regards to posture, anthropometric measures and dynamometric adjustments (Jason, 2007).

Strong correlations have been reported between grip strength and body dimensions like weight, height, and hand length (Koley and Yadav, 2009; Kaur, 2009).
The results for correlations between handgrip strength and body mass index are controversial: some authors have reported that static grip strength is positively related to body mass index (BMI), considering it to be a predictor for grip strength, while others found no significant association, concluding that BMI does not influence handgrip strength (Mahmut, 2016; Chelliah and Rizam, 2018).

The assessment of hand grip strength assumes importance in a number of situations. It may be used in the investigation and follow-up of patients with neuromuscular diseases (Charles and Burchfiel, 2006; Foo, 2007). It is also of use as functional index of nutritional status and can predict the extent of complications following surgical intervention in hospitalized patients (Shyamal and Arvinder, 2010).

This study is designed to evaluate the effect of sex, age, anthropometric parameters and posture on HGS in young adult Nigerians, aged 18-45 years old who are students of the Ahmadu Bello University, Zaria.

MATERIALS AND METHODS

This study was conducted in Samaru Campus of the Ahmadu Bello University, Zaria, Kaduna State of North-Western Nigeria. Under-graduate and post-graduate students of the university that were within the age range of eighteen (18) to forty five (45) years were recruited for the study. Six hundred and twelve (612) subjects male (n=302) and female (n=310), participated in the study.

Inclusion and Exclusion Criteria
Apparently healthy participants not suffering from any of the musculoskeletal diseases, age 18 – 45 years and right-handed participants were included in this study while individuals with fractures of the hand, forearm and arm, contractures, injuries of the hand, neurological conditions, skin conditions like dermatitis, psoriasis, body builders and left handed subjects were excluded from the study

Materials
The materials used in this study were a stadiometer (Model RGZ 160, China), vernier slide calliper (Starrett, 123 Series, U.S.A.), measuring tape (Butterfly, China), baseline hydraulic hand dynamometer (Fabrication Enterprise Inc. Irvington, NY) and a straight – backed chair

Informed Consent
Informed consent for inclusion into the study was obtained from the subjects that participated in this study.

Ethical Consideration
Ethical approval was obtained from the Ahmadu Bello University Teaching Hospital Health Research Ethics Committee.

Sampling Technique
The data for the study were randomly collected from students of Ahmadu Bello University. The nature of the study was fully explained to the participants.

Anthropometric Measurements
All anthropometric measurements were carried out following standard protocols as described by Lohman *et al,* (1988).

The height and weight of each participant was taken using a standard meter rule and a weighing scale that recorded to the nearest 0.1kg with the subject standing upright on a stadiometer placed on a flat ground.

The hand length and breadth of each participant was measured to the nearest 0.1mm using a vernier slide caliper. The participant's hand was extended, with the palm in a supine position. The hand length was measured as a straight distance between the distal crease of the wrist joint and the tip of the middle finger. The hand breadth was measured as a straight distance from the most laterally placed point on the hand of the second metacarpal to the most medially placed point located on the hand of the fifth metacarpal.

The forearm length was measured to the nearest 0.1cm using a tape rule. Participants were in standing position, elbow flexed at 90^0 with forearm and wrist in neutral position and in front (anterior) of the body. The forearm length was measured as the distance from the olecranon process of the ulnar to the tip of the styloid process of the ulnar.

The arm length was measured using a tape rule that measure to the nearest 0.1cm. Participants were in standing position with the arm held parallel to the side of the body and the forearm held against the body perpendicular to the arm. The arm length was measured as the distance from the bony protrusion on the shoulder (acromion process of the scapula) to the point of the elbow (olecranon process of the ulna).

The MAC was measured to the nearest 0.1cm using a tape rule. The midpoint of the arm length is marked on the skin on both sides of the measuring tape. With the participant's upper extremity hanging relaxed at the side, the horizontal arm circumference was measured at the marked midpoint.

The body mass index was calculated by dividing the weight in kilogram (kg) by the square of the height in meters (m^2).

$$BMI = weight (kg)/height (m^2)$$

Hand Grip Strength Measurement
The grip strength of the dominant (right) hand was measured in kilogram (kg) using a standard adjustable Baseline Hydraulic Hand Dynamometer (Fabrication Enterprise Inc. Irvington, NY) at standing position with shoulder adducted and neutrally rotated, elbow in full extension with forearm and wrist in a neutral position.

A standard position for testing HGS recommended by the America Society of Hand Therapists (ASHT) requires that the subject sits in a straight-backed chair, feet flat on the floor, shoulders adducted in neutral, arms unsupported, elbows flexed at ninety degrees(90^0), forearm in neutral rotation, wrist in 0-30 degrees dorsiflexion and 0-15 degrees ulnar deviation (Andrew and Stuart, 2004).

Grip strength measurement was performed in both outlined positions (standing with elbow in full extension and sitting with elbow in 90^0 flexion). The test was performed at the second setting of the dynamometer as suggested by ASHT (1992) guidelines. The participants were asked to put maximum force on the dynamometer thrice, with a ten (10) seconds rest between tests to avoid fatigue. The average value was recorded in kilograms.

Statistical Analyses
Data were expressed as mean ± standard deviation (SD). Students t-test was used to investigate difference between males and females in HGS, forearm length, arm length, mid arm circumference and hand dimensions. One way ANOVA was used to investigate difference in HGS and the other variables according to age groups. $P < 0.05$ was deemed statistically significant. Data was analysed using SPSS version 20 (IBM Corporation, NY).

RESULTS
Six hundred and twelve (612) participants, comprising undergraduate and post graduate students of the Ahmadu Bello University, Zaria, male (n=302) and female (n=310), age range 18 to 45 years participated in this study. The subjects were divided into three age groups of 18-25 (n=266), 26-35 (n=269) and 36-45 (n=76).

Comparison of HGS in sexes of participants showed sexual dimorphism; males had significantly (p<0.001) higher HGS than females (Figure 1).
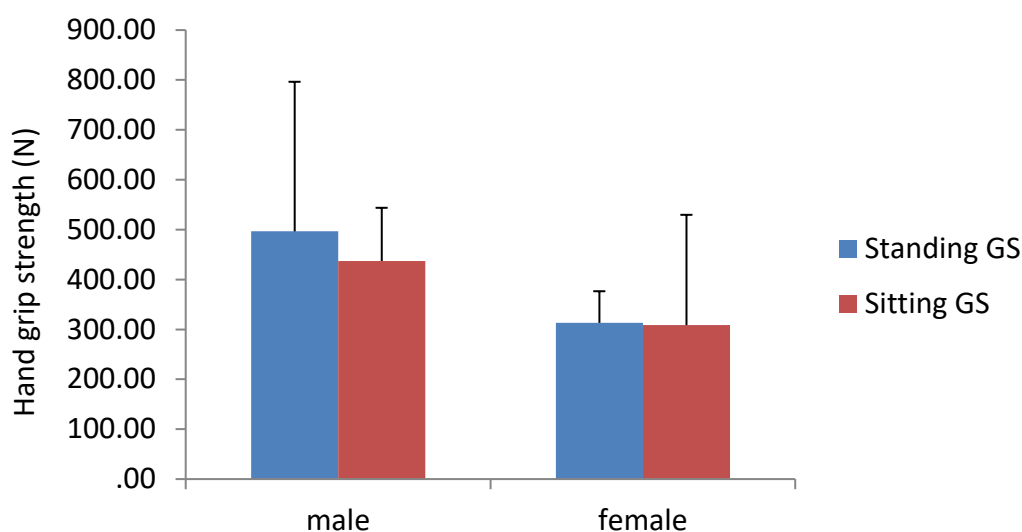Anthropometric variables were higher in males, except for BMI (Table 1).

Figure 1: Comparison of hand grip strength in sexes of subjects studied.n =302(male); n=310(female), Mean ± SD; Independent sample *t*-test, p<0.001. GS=Grip strength.

Table 1: Sexual dimorphism in anthropometric variables of studied participants

Variables	Male (n=302) Mean ± SD	Female (n=310) Mean ± SD	T	p-value
Hand Breadth (mm)	89.54 ± 8.82	82.19 ± 5.42	12.448	0.000
Hand Length (mm)	199.17 ± 107.16	181.21 ± 13.26	2.928	0.004
Forearm Length (cm)	31.04 ± 15.97	28.10 ± 2.23	3.205	0.001
Arm Length (cm)	39.56 ± 3.38	38.67 ± 20.06	0.761	0.447
Mid Arm Circumference (cm)	30.98 ± 17.17	29.64 ± 4.62	1.324	0.186
Height (m)	1.72 ± 0.08	1.61 ± 0.08	15.443	0.000
Weight (kg)	71.30 ± 16.65	66.44 ± 15.54	3.734	0.000
Body Mass Index (kg/m²)	24.30 ± 6.18	25.73 ± 6.78	-2.719	0.007

n=612; Independent sample *t*-test.

In the overall population (male + female) HGS in standing and sitting showed participants in the age range of 26-35years, had higher values (p<0.05) of grip strength in both posture (Figure 2).

The anthropometric variables in age categories of studied participants revealed that there was an increase in the anthropometric variables of MAC, HT, WT and BMI in relation to the age categories of 18-25 through 36-45 years. However, no pattern (either increase or decrease) was observed for HB, HL, FAL and AL in relation to the age categories. The relationship between the age categories and anthropometric variables showed significant difference only in WT and BMI (Table 2).
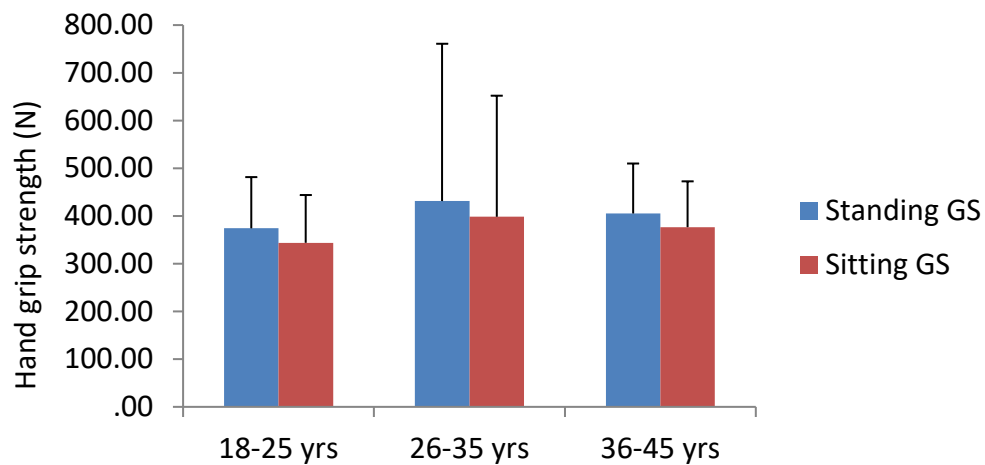
Figure 2: Relationship between HGS and age categories of subjects
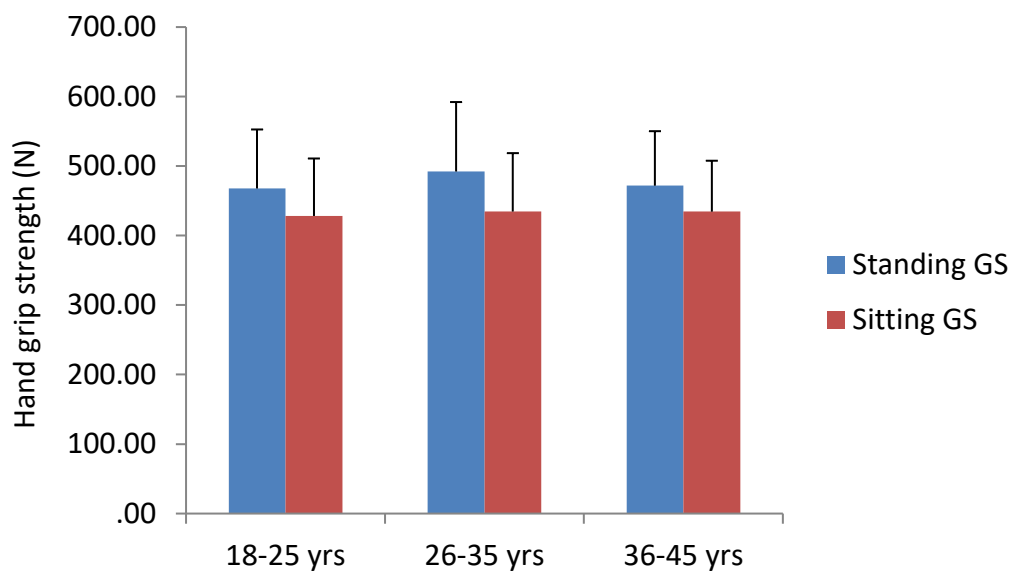n=266(18-25years); n = 269(26-35years); n=76(36-45years), Mean ± SD.

Figure 3: Relationship between HGS and age categories in male participants
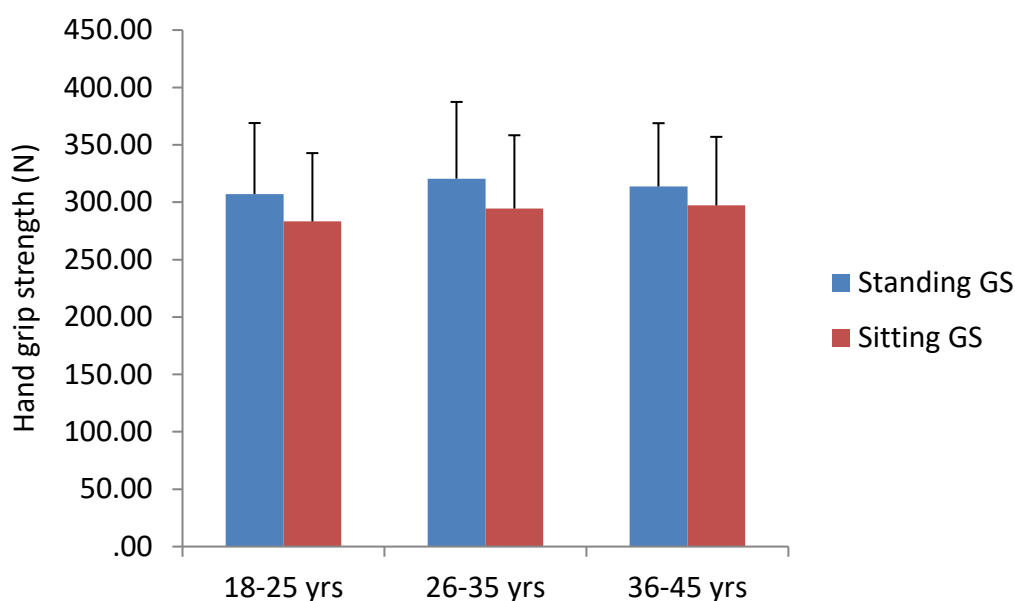Mean ± SD.

Figure 4: Relationship between HGS and age categories in female participants
Mean ± SD.

Table 2: Anthropometric parameters in age categories of studied participants

Variables	18-25 (n=266) Mean ± SD	26-35 (n=269) Mean ± SD	36-45 (n=76) Mean ± SD	F	P
Height (m)	1.66±.10	1.67±.10	1.68±.09	1.8792	0.132
Weight (kg)	63.16±11.40	71.35±18.82	79.51±13.11	7.6882	0.000
BMI(kg/m²)	23.22±4.54	25.85±7.90	28.42±4.98	4.332	0.000
Hand Breadth (mm)	85.75±9.56	85.65±6.85	86.67±7.18	0.477	0.621
Hand Length (mm)	187.83±21.33	192.79±112.41	188.34±25.71	0.203	0.894
Forearm Length (cm)	39.68±176.36	41.08±176.09	28.99±2.30	0.110	0.954
Arm Length (cm)	39.76±21.67	38.43±3.17	39.15±2.67	0.382	0.766
Mid Arm Circumference (cm)	29.55±18.31	30.27±4.18	32.97±3.73	1.511	0.211

DISCUSSION

In this study, six hundred and twelve (612) participants; undergraduate and post graduate students of the Ahmadu Bello University, Zaria, male and female, between the ages of eighteen to forty-five (18 - 45) years were categorized into age groups. Participants' HGS were measured in standing and in sitting positions and analysed according to variation through the age groups and anthropometric variables were measured and analysed through the age groups.

Sexual dimorphism is a phenotypic difference between males and females of the same species (Maina *et al.*, 2011; Kumar and Muzzafar Lone, 2013). Hand grip strength is a physiological variable that is affected by a number of factors including age, sex and body size (Koley *et al.*, 2009). In this study, comparison of HGS in standing and in sitting positions in relation to sex revealed sexual dimorphism; males had shown higher HGS values than their female counterpart. Comparing anthropometric characteristics, relative to sex, it was revealed that there was sexual dimorphism; values were higher in males than their female counterpart, except for body mass index (BMI). Results revealed significant sexual dimorphism in all the studied anthropometric variables, except in AL and MAC. Findings are in concordance with

previous research studies demonstrating stronger grip for men than women (Chatterjee and Chowdhuri, 1991; Bohannon *et al.,* 2006; Charles and Burchfiel, 2006; Ibegbu *et al.,* 2014). It has been reported earlier that men possessed considerably greater strength than women for all muscle groups tested (McArdle *et al.*2001; Bohannon *et al.,* 2006; Shyamal and Satinder, 2011). The hand bones have been documented as good anthropometric parameters and had proven to exhibit great sexual dimorphism (Ibeachu *et al.,* 2011). In adults, sexual differences are evident in hand length measurements and in hand width to length ratios (McFadden and Shubel 2002). A study of sexual dimorphism in hand and foot length, indices, stature-ratio and relationship to height in Nigerians has been reported (Danborno and Elukpo, 2008). The difference in hand dimension between male and female, as observed in the present study, could be explained as part of genetic expression of male being larger than female (Ibeachu *et al.,* 2011).

The anthropometric values obtained from this study were similar to those from other studies within Nigeria and some other countries. Taura (2011) researched on anthropometric status of Hausas of northern Nigeria and observed in all the parameters measured males had higher values than females, except for BMI which was higher in females than in males. Ibegbu *et al.* (2014) worked on Nigerian students (14 – 18 years) resident in Kano state and showed that male students had higher mean values for all the tested anthropometric variables than the females, except for BMI and MAC.

The values for anthropometric variables, such as, HT, WT, and BMI were slightly higher compared to what was obtained in Nigerians residing in Kano State (Taura, 2011), and that reported of Bisai *et al.* (2008) among adults (18 – 65 years) in Kora Mudis, a tribal population of Bankura District, West Bengal, India.

Based on the results, the present study has demonstrated that, there exists sexual dimorphism in the studied participants; males are generally taller, weightier, and have longer hand length, hand breadth, forearm length, arm length and mid arm circumference, with higher HGS than their female counterparts, while females on the other hand, had higher BMI than their male counterparts. This is in coherence with the study conducted by Shyamal and Sartinder (2011), which reported that males have higher mean values of all the anthropometric parameters than females.

The possible explanations for the difference in HGS are the difference in the type of activity of each gender. Males are more active than females and perform more physical work. Sometimes males are involved in more weight handling than their female counterpart and due to higher fat deposition in females as compared to males. Also the existence of greater percentage of muscularity among male students than their female counterparts may be because of the regular exercise of the males that prevented the accumulation of fat in the body (McArdle *et al.,* 2001; Foo, 2007; Prakash *et al,* 2011).

In this study, HGS and anthropometric variables were analysed for relationship and compared in relation to three age categories (18-25, 26-35 and 36-45 years).

Results revealed relationship between age categories and HGS in standing and sitting positions and showed remarkably higher values of grip strength in participants with age range of 26-35 years. An 'inter-age-range' comparison of HGS revealed higher HGS values in

26-35 years than 18-25 years participants; higher HGS values in 36-45 years than 18-25 years participants, and higher HGS values in 26-35 years than 36-45 years participants.

Muscle strength declines with advancing age amongst men and women (Rosmalina *et al.,* 2001; Basuki, 2008). Organ function naturally declines in the elderly, for example changes to the musculoskeletal system in the form of degenerative loss of muscle mass (sarcopenia) and decreased muscle strength lead to various body dysfunctions (Budiharjo and Soebijanto, 2004). Loss of muscle strength decreases the body's ability to balance and disrupts functional mobility (Basuki, 2008). Findings of this study are consistent with previous researches demonstrating that, HGS decreases with advancement in age (Chatterjee and Chowdhuri, 1991; Bohannon *et al.,* 2006; Charles and Burchfiel, 2006; Basuki, 2008). A decrease in muscle grip strength in older people is caused by structural changes in the hands, including the joints, muscles, tendons, bones, blood vessel supply, skin and neurological control (Carmeli *et al.,* 2003). Some studies have revealed that muscle strength tends to decline with age(Rosmalina *et al.,*2001; Basuki, 2008;Darmojo, 2011; Hutasuhut and Ryoto, 2014).

It has been established that, a curvilinear relationship exists between HGS and age; resulting in an initial increment of hand grip strength with the increase in age reaching a peak during the third decade, followed by a decrease as the aging process progresses, and culminating with decline after the fifth decade (Kamarul *et* al 2006; Vianna *et al* 2007; Gunther *et al* 2008; Andersen-Ranberg*et al* 2009; Massy-Westropp *et al* 2011). Varying as a function of age, highest grip strength scores occur between the ages 25 and 39 years (Mathiowetz *et al.,* 1985). Sella (2001) also reported that HGS increases with age up to 20-39years and tends to decrease thereafter.

Lauro *et al,* (2007) reported that men's HGS reaches a peak at 30 years and then decreases with increasing age. Abazar *et al.* (2011), in their study of the effect of aging on HGS, reported that grip strength started recording a gradual decline in the third decade of life.

In this study, the values of anthropometric variables, such as, MAC, HT, WT and BMI increased in relation to age group (from 18-25 through 36-45 years). However, an irregular relationship (either increase or decrease) was observed for HB, HL, FAL and AL in relation to the age categories. 'Inter-age-range' comparison of studied anthropometric variables revealed higher anthropometric values in 26-35 years than 18-25 years, except in HB and AL; higher anthropometric values were recorded in 36-45 years than 18-25 years participants except in FAL and AL, and 36-45 have higher values than 26-35 years, except in HL and FAL.

Ibegbu *et al.* (2013) in their study observed gradual increase in the values of anthropometric characteristics, such as, HT, WT and BMI as age increases in children. Ibeachu *et al.* (2011) observed gradual increase in the values of hand dimensions with age increase in adult males. An explanation for variability in the studied anthropometric variables with respect to age category, in the present study, could be based on the normal anatomical or structural changes that manifest with the process of growth. In bone development, the epiphysial fusion of bones occurs progressively from puberty to maturity. Most bones take many years to grow and mature. The humerus (arm bone), for example, begins to ossify at the end of the embryonic period (8 weeks); however, ossification is not complete until age 20 (Moore *et al.,* 2014).

CONCLUSION

Sexual dimorphism exists in the sexes of participants studied: males had remarkably higher values of HGS in standing and in sitting positions when compared with their female counterpart; the anthropometric variables were higher in males, except for BMI, when compared to their female counterpart. HGS has a curvilinear relationship with age; participants in the age range of 26-35years had higher grip strength values in both standing and sitting positions. Anthropometric variables of MAC, HT, WT and BMI increased in relation to age categories 18-25 through 36-45 years and exert influence on HGS.

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