

## **ANTHROPOMETRIC CORRELATES OF HANDGRIP STRENGTH AMONG PRIMARY SCHOOL PUPILS**

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### **Abstract**

**Study aim:** This study investigated the interdependence of anthropometrics with handgrip strength (HGS) among primary school pupils. **Materials and methods:** A total of 200 primary school pupils participated in this study. Electronic handgrip dynamometer was used to measure HGS in kg, body height and body weight were measured with a wall-mounted stadiometer in meters and bathroom weighing scale in kg respectively. In addition, forearm circumference was measured at the largest part of the forearm and maximum hand width was taken for hand circumference. The relationship between HGS and anthropometric parameters was analyzed using Pearson's product moment coefficient of correlation. **Results:** The outcome of this study showed that age correlated disproportionately but significantly ( $p < 0.05$ ) with HGS. Also, body weight, BMI and handedness were found to associate proportionately and significantly with HGS. However, hand and forearm circumferences were observed to relate positively but insignificantly ( $p > 0.05$ ) with HGS. **Conclusion:** This study therefore concluded that the most important determinants of HGS among primary school pupils are body weight, BMI and handedness and thus, could be considered as markers of nutritional and health status, as well as physical fitness of these individuals.

**Keywords:** Anthropometrics, handgrip strength and primary school pupils

### **Introduction**

Wellbeing and proper fitness of musculoskeletal system is one of the important factors needed to carryout daily activities. However, physical fitness has been identified as a predictor of morbidity and mortality in the young. In particular, muscular fitness has been proven to be associated with insulin sensitivity in both children and adolescents which, in turn, is linked to the future risk of type 2 diabetes mellitus (T2DM) in adulthood (Sabin, Magnussen, Juonala, Shield, Kahonen & Lehtimaki, 2015). In this regard, handgrip strength (HGS) is a reliable clinical index of muscular fitness, commonly used in both children and adults as a marker of nutritional and health status as well as general body strength (Schlussel, Anjos & Kac, 2008). In fact, an association between some micronutrient deficiencies, which are common in young people and HGS, has been documented (Valtuna, Gracia-Marco, Huybrechts, Breidenassel, Ferrari & Gottrand, 2013). It has also been reported that physical performance has a strong association with body strength, shape, size, form and structure of an individual (Foo, 2007).

HGS is a widely used test in experimental and epidemiologic studies in children. This is because HGS is a physiological variable that is affected by a number of demographic and anthropometric variables including age, gender, handedness, hand and forearm circumferences, body height and body weight among others (Baskaran, Arindam, Chandan & Bidhan, 2010; Ruiz, Ortega, Gutierrez, Meusel, Sjostrom & Castillo, 2006). Consequently, muscle strength is impaired in overweight or obese persons and this impairment may be as a result of both sedentary lifestyle and low physical fitness. In addition, poor muscle strength is found to be associated with low body weight and poor nutritional status and most studies conducted before now have attempted to associate HGS with anthropometric variables to predict the outcome of the former (Mandahawi, Imrhan, Al-Shobaki & Sarder,

2008). Several factors including gender, age, body height, body weight, body mass index (BMI) and handedness have been shown to affect HGS performance (Deepak, Laxmikant & Rasika, 2014; Liao, 2014). In the study of the relationships of HGS with stature, weight, arm and calf circumferences and various subcutaneous skin folds, it was found that males attained greater values for those anthropometric variables and also have greater HGS values than their female counterparts (Montalcini, Ferro, Salvati, Romeo, Miniero & Pujia, 2016). Moreover, studies have shown that there was age dependent increase in HGS in boys and girls and inter-gender differences have also been found to strongly associate with changes of fat free mass during childhood (Prakash, Dhara & Sujaya, 2011). In 2007, Visnapuu and Jurimae stated in their study that body weight and stature (body height) are primary indicators of human growth, and concluded that there are highly significant relationships between maximal HGS of the dominant hand and general anthropometric variables in all age groups including hand, wrist and forearm circumferences, hand length and so on in all age groups. Other important anthropometric parameters that have been found to affect HGS are grip span, hand length and hand span (Ruiz, Espana-Romero et al., 2006). In effect, many HGS studies in young healthy individuals have revealed that anthropometrics such as body height, body weight, BMI, hand length, hand circumference, grip span, are positively associated with HGS (Vaz, Hunsberger & Diffey, 2002). In addition, Das and Dutta (2015) reported a significant positive correlation between BMI and HGS and handgrip endurance in different weight groups among apparently healthy male and female individuals. Similarly, in the study of the anthropometric correlates of motor performance among Malaysian University athletes, it was found that all anthropometrics were found to be significant contributors to strength, vertical jump and cardiovascular endurance (Amri, Ujang, Wazir & Ismail, 2012). Likewise, Bansode, Borse and Yadav (2014) found a significant positive correlation between dominant HGS with age, body height, body weight, BMI and hand span of dominant hand in males and females. They also reported that persons with longer fingers and larger hand surfaces enjoy stronger grip power. Other researchers have examined a number of factors and anthropometric variables that explain this relationship (Hemberal, Doreswamy & Rajkumar, 2014).

It is worth noting that body weight, body height, hand length, forearm length, forearm, hand and wrist circumferences and other anthropometrics are significantly different between the young and the old individuals. Several studies (Das & Dutta, 2015; Deepak et al., 2014; Mandahawi et al., 2008) have been extensively conducted to bring forth the relationship of various anthropometric variables and HGS in adult population. Unfortunately, there is insufficient data of such in younger individuals especially among Nigerian population. Nevertheless, Ibegbu, Baita, Hamman, Emmanuel and Musa (2014) evaluated the relationship between HGS with some anthropometrics among Nigerian secondary school students. Therefore, relationship of HGS and anthropometrics among Nigerian primary school pupils are also very necessary to identify children with malnutrition or at risk of other associated clinical complications of limited HGS and to plan appropriate therapeutic interventions. This study therefore, aims at analyzing the interdependence of HGS with anthropometric variables among primary school pupils.

## **Research hypotheses**

The following hypotheses were formulated and tested at 0.05 alpha level.

Hypotheses:

1. There will be no significant relationship between age and HGS among primary school pupils.
2. There will be no significant correlations between body height and HGS, and body weight and HGS respectively among primary school pupils.
3. There will be no significant relationship between BMI and HGS among primary school pupils.
4. Hand dominance (handedness) would not significantly correlate with HGS among primary school pupils.
5. There will be no significant relationships between hand circumference and HGS, and forearm circumference and HGS respectively among primary school pupils.

## **Materials and methods**

### *Research design*

This study is a correlational survey design of anthropometric correlates of HGS among primary school pupils.

### *Population*

The population for this study included primary school pupils between the biological ages of 7 to 10 years from three primary schools in the 2015/2016 academic session in Oyo State, Nigeria.

### *Sample size and sampling technique*

A total of one hundred (100) male and one hundred (100) female primary school pupils participated in this study. They were recruited using proportionate random sampling technique. However, participants with any joint problems of hand, wrist and elbow, history of fracture, neurological disorder, and deformities of upper limb were excluded from the study.

### **Measurements and Data collection**

The study received ethical approval from the Research Ethics Committee of the University of Benin, Nigeria to conduct this study and the participants were then recruited consecutively. HGS was measured using a Camry Electronic Hand Dynamometer (Model: EH101). This device comes with dual scale readout of forces in kilograms and pounds. However, all readings were recorded in kilograms in the present study. To standardize the test, the following guidelines were established; the arm positioning followed the American Society of Hand Therapists guidelines (Fess, 1992), with the participant comfortably seated and the shoulder slightly forward with the elbow flexed at a 90° angle. The forearm and wrist were in a neutral position. Three maximum efforts were performed alternately for each arm, with three-second contractions and ten-second rest periods between the attempts. The best of three attempts was recorded.

The following test instructions were provided: “you must squeeze the handle as hard as possible keeping both your body and arm in position”. The same tone was used during the briefings, and no verbal encouragement was offered. The instrument calibration was assessed periodically throughout the study. Also, age and hand dominance (the one which is preferred for daily activities such as writing and eating) were recorded.

The standing heights were measured using a stadiometer. Each participant was assessed while in good standing posture on the foot resting on the device with minimal clothing, without shoes but with the head facing forward in front foot position. The participants also had their shoulders relaxed, arms hanging loosely on both sides, palms facing forward, feet together and knees straight. The height for each participant was taken when the movable headboard was lowered to touch the vertex of the head. The measurements were taken to the nearest 0.1cm.

The calibrated weighing scale was used to measure body weight and was checked for zero balance before each use. Participants were instructed to empty their pockets and remove shoes and any apparel that could interfere with weight measurements. They then stood on the scale looking straight ahead, relaxed and remained motionless without leaning on any object or the wall. Weight measurements were taken when the scale stabilized and recorded to the nearest 0.1kg while protecting the confidentiality of the participants' values. BMI was then calculated using the formula: weight (kg)/height (m<sup>2</sup>).

Hand dimension measurements were made by a standard flexible measuring tape to the nearest centimeter with the hand extended and relaxed while the elbow was supported on a table. Forearm circumference was measured at the largest part of the forearm and also maximum hand width was taken for hand circumference.

### **Data analysis**

The data obtained from this study were analyzed using descriptive and inferential statistics. Anthropometric profile of the participants was summarized using frequency counts, percentages, mean and standard deviation. Relationship between HGS and anthropometrics were analyzed using Pearson's product moment coefficient of correlation. All inferential analyses were performed at 0.05 alpha levels using the Statistical Package for the Social Sciences (SPSS) version 20.0.

## Results

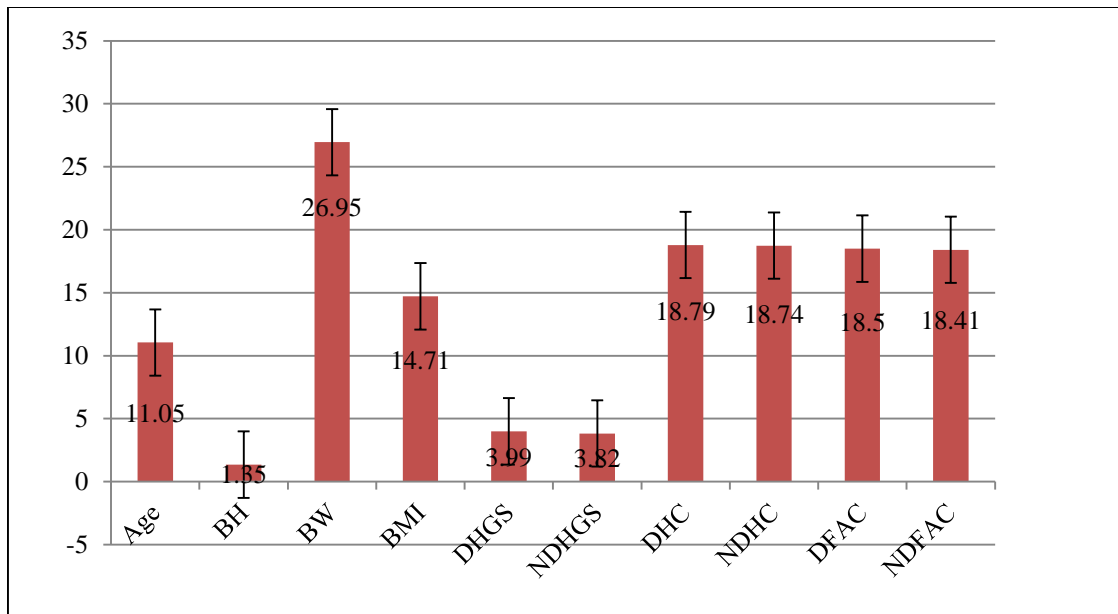
The results are presented in Tables 1 and 2.

The descriptive statistics of the studied anthropometric parameters in the general population sample showing the mean and standard deviation values for each variable are presented and represented in Table 1 and Figure 1 respectively. The relationship between anthropometric parameters and HGS is showed in Table 2.

**Table 1:** Anthropometric profile of participants.

Variables	n (%)	M ± SD
Gender		
Male	100(50)	--
Female	100(50)	--
Age	--	11.05±0.82
BH	--	1.35±0.63
BW	--	26.95±4.22
BMI	--	14.71±1.89
DHGS	--	3.99±0.75
NDHGS	--	3.82±0.82
DHC	--	18.79±1.25
NDHC	--	18.74±1.26
DFAC	--	18.50±1.34
NDFAC	--	18.41±1.32

n=frequency within a group or subgroup, %=percentage within a group or subgroup, M± SD=mean± standard deviation, BH-body height (m), BW-body weight (kg), BMI-body mass index (kg/m<sup>2</sup>), DHGS- dominant handgrip strength (kg), NDHGS-non dominant handgrip strength (kg), DHC–dominant hand circumference (cm), NDHC- non dominant hand circumference (cm), DFAC- dominant forearm circumference(cm) and NDFAC- non dominant forearm circumference (cm).



BH-body height, BW-body weight, BMI-body mass index, DHGS- dominant handgrip strength, NDHGS-non dominant handgrip strength, DHC –dominant hand circumference, NDHC- non dominant hand circumference, DFAC- dominant forearm circumference and NDFAC- non dominant forearm circumference.

**Figure 1:** Graphical representation of the mean and standard error values of the studied anthropometric parameters

**Table 2:** Correlations of participants' anthropometric parameters with HGS.

	Age	BH	BW	BMI	DHGS	NDHGS	DHC	NDHC	DFAC	NDFAC
Age	1									
BH	0.017 0.816	1								
BW	-0.007 0.925	0.588*	1							
BMI	-0.073 0.303	-0.018 0.805	0.794** .000	1						
DHGS	-0.141* 0.047	0.019 0.794	0.350** 0.000	0.454** 0.000	1					
NDHGS	-0.142* 0.047	0.017 0.815	0.360** 0.000	0.445** 0.000	0.850** 0.000	1				
DHC	0.042 0.551	-0.008 0.914	0.096 0.175	0.110 0.120	0.082 0.249	0.053 0.458	1			
NDHC	0.044 0.534	-0.004 0.957	0.093 0.189	0.103 0.147	0.083 0.243	0.049 0.490	0.998* 0.000	1		
DFAC	0.158 0.026	0.135 0.057	0.160* 0.023	0.087 0.223	0.001 0.992	-0.014 0.844	0.154* 0.029	0.156* 0.028	1	
NDFAC	0.165 0.019	0.133 0.060	0.154* 0.030	0.079 0.267	0.017 0.812	-0.030 0.678	0.154* 0.029	0.156* 0.027	0.997* 0.000	1

BH-body height, BW-body weight, BMI-body mass index, DHGS- dominant handgrip strength, NDHGS-non dominant handgrip strength, DHC –dominant hand circumference, NDHC- non dominant hand circumference, DFAC- dominant forearm circumference and NDFAC- non dominant forearm circumference.

### *Hypotheses testing*

#### *- Hypothesis 1*

There will be no significant relationship between age and HGS among primary school pupils. The findings from this study indicated that there is a significant ( $p < 0.05$ ) but disproportionate relationship (DHGS,  $r = -0.141$ ; NDHGS,  $r = -0.142$ ) between age and HGS; hence the null hypothesis ( $H_0$ ) was rejected. This implies that as the age increases the HGS decreases and vice versa.

#### *- Hypothesis 2*

There will be no significant correlations between body height and HGS, and body weight and HGS respectively among primary school pupils.

It was observed from this study that a proportionate (DHGS,  $r = 0.019$ ; NDHGS,  $r = 0.017$ ) but insignificant ( $p > 0.05$ ) relationships exist between body height and HGS and therefore,  $H_0$  was retained. This implies that height is not a determinant of HGS among primary school pupils and any relationship noticed can be attributed to chance factor. Findings from this study however, indicated that there is proportionate (DHGS,  $r = 0.350$ ; NDHGS,  $r = 0.360$ ) and significant ( $p < 0.05$ ) relationships between body weight and HGS; hence the  $H_0$  was rejected. This implies that being weighty does influence HGS among primary school pupils.

#### *- Hypothesis 3*

There will be no significant relationship between BMI and HGS among primary school pupils. This study showed that BMI is a proportionate (DHGS,  $r = 0.454$ ; NDHGS,  $r = 0.445$ ) and significant ( $p < 0.05$ ) correlate of HGS and therefore the  $H_0$  was rejected. This is an indication that BMI is a predictor of HGS among primary school pupils.

#### *- Hypothesis 4*

Hand dominance (handedness) would not significantly correlate with HGS among primary school pupils. It was observed from this study that a proportionate ( $r = 0.850$ ) and significant ( $p < 0.05$ ) difference exists between DHGS and NDHGS. Therefore,  $H_0$  was rejected, implying that handedness is a determinant of HGS among primary school pupils.

#### *- Hypothesis 5*

There will be no significant relationships between hand circumference and HGS, and forearm circumference and HGS respectively among primary school pupils.

A proportionate but insignificant correlations ( $p > 0.05$ ) exist between dominant and non-dominant hand circumferences and HGS (DHC,  $r = 0.082$ ; NDHC,  $r = 0.083$ ) as well as NDHGS (DHC,  $r = 0.053$ ; NDHC,  $r = 0.049$ ). The  $H_0$  was therefore retained. This implies that hand circumference cannot predict HGS among primary school pupils. It was also uniquely observed from this study that a proportionate but insignificant ( $p > 0.05$ ) relationship (DFAC,  $r = 0.001$ ; NDFAC,  $r = 0.017$ ) exists between dominant and non-dominant forearm circumferences and DHGS. Also, a disproportionate and insignificant ( $p > 0.05$ ) relationship (DFAC,  $r = -0.014$ ; NDFAC,  $r = -0.030$ ) exists between dominant and non-dominant forearm circumferences and NDHGS. Therefore,  $H_0$  was retained, implying that hand circumference cannot determine HGS among primary school pupils.

## **Discussion of findings**

The principal outcome of this study indicated that of all the anthropometric variables evaluated, body height, hand and forearm circumferences were not significantly correlated with HGS. Factors such as age, body weight, BMI and handedness associated significantly with HGS. The significant and disproportionate relationship between age and HGS suggests that as the age increases, the HGS decreases and vice versa among primary school pupils as also reported in other studies elsewhere (Baskaran et al., 2010; Liao, 2014). The effect of maturity and growth may result in higher percentage of skeletal muscle mass development. Likewise, the larger standard deviation in the pupil's age range could potentially affect the findings of the study. These, in turn, could be responsible for total body strength and by implication affect the execution of some skills requiring the use of the hand and involving physical demands.

Body height was found in this study to have a direct correlation with HGS though such correlation was not significant. This is in contrast to the study of Visnapuu and Jurimae (2007) and Lee, Kim, Paik, Jang, Chang, Baek and Gong (2012) that indicated body height as a primary indicator of human growth and significantly associated with HGS in all age groups. This contrasting finding might not be unconnected to variation in study methodology including subject characteristics, differences in measuring instruments of HGS. Therefore, with respect to this study, being taller is not a predictor of better HGS. On the contrary, body weight was found to have a significant and proportionate relationship with HGS, indicating that being weighty does influence HGS among primary school pupils. This might equally be as a result of higher percentage of skeletal muscle mass but not percentage fat mass which can largely be responsible for body heaviness thereby resulting in better or higher HGS. This, by implication, means that students who are weighty are at advantage of being stronger and less predisposed to morbidities related to reduced muscular strength. Previous studies have reported similar finding that body weight influences HGS among young individuals (Deepak et al., 2014; Visnapuu & Jurimae, 2007; Bansode et al., 2014). In contrast, the study of Gunter, Burger and Rickert (2008) showed that HGS correlated best with body height in both gender and body weight was correlated in men, but not in women with HGS among Caucasians. This contrasting finding could simply be as a result of subject characteristics of being black individuals.

This study suggests that BMI influences HGS. Related studies showed that low BMI is associated with poor HGS and vice versa (Das and Dulta, 2015; Vas et al., 2002). The implication of this is that being younger may be responsible for recording low BMI because of small percentage of muscle mass resulting in poor HGS. Handedness was found to relate positively and significantly to HGS in this study. This might not be a surprise because the constant use of a particular hand tends to be stronger according to the principle of reversibility (use it or lose it). This finding is supported by the findings of Baskaram et al. (2010) who reported that HGS is affected by handedness and Visnapuu and Jurimae (2007) who concluded that dominant hand is significantly and proportionately related to HGS.

Furthermore, hand circumference was observed to associate proportionately but insignificantly with HGS in this study. This finding is not in agreement with the study of Ruiz et al. (2006). This disagreement might not be unconnected to variation in study methodology including subject characteristics, differences in measuring instruments of HGS and the like. Therefore, larger hand circumference is not a predictor of better HGS according to this study. Also, forearm circumference was found to correlate proportionately with DHGS but disproportionately with NDHGS although all are insignificant. In contrast, the study of Mohan, Shamsaimon, Japri, Yasin, Henry and Othman (2014) showed that forearm circumference is a primary indicator of human growth and significantly associated with HGS in all age groups. These contrasting findings might be due to variation in study methodology.

## Conclusion

Body weight, BMI and handedness were found to associate proportionately and significantly with HGS. Also, hand and forearm circumferences were observed to relate positively but insignificantly with HGS. However, age was found to correlate significantly but disproportionately with HGS among primary school pupils. It is expected that the findings of this study:

- May be useful in the process of talent identification in sports involving the use of handgrip.
- Might serve as an index to the government and healthcare providers in policy making as regards relationship between anthropometrics and HGS and also as a marker of nutritional and health status as well as physical fitness.
- May also establish a simple model to predict maximal grip strength in dominant hand.

From the result of this study, it is highly recommended that further studies be conducted to evaluate the association between HGS and other anthropometric variables in male and female samples including hand length, palm length, handgrip span, hand span and so on.

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