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Evaluation of the Relationship between Handgrip Strength with Some Anthropometries among Nigerian Secondary School Students

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ABSTRACT The aim of the present study was to evaluate the relationship between handgrip strength and some anthropometric variables in 400 randomly selected Secondary School Students in Kano, Nigeria. The students were from two secondary schools and were aged 14-18 years with mean age of 16.00±1.35. The anthropometric variables namely, the height, weight, BMI, hand width and length, upper and lower arm length, mid upper arm circumference (MUAC) and handgrip strength were measured using standard anthropometric measurement techniques. The results from the present study showed that male students had higher mean values in seven variables namely, the height (16.00±1.35kg), weight (46.34±8.30cm), hand length (19.34±0.98cm), hand width (10.45±0.90cm), forearm length (27.93±1.92cm), arm length (31.93±2.46cm), handgrip strength (35.63±17.17), and lower mean values in two variables namely, BMI (17.45±2.30) and MUAC (24.23±2.26cm). In male students, handgrip strength had significant positive correlations (Pd"0.01) with all the variables studied while in the female students, handgrip strength had a significant positive correlation (P≤0.01) with some of the variables studied. It may be concluded that handgrip strength had strong positive correlations with all the anthropometric variables studied in Nigerian Secondary School Students of Kano metropolis.

INTRODUCTION

Hand grip strength is a physiological variable that is affected by a number of factors including age, gender and body size among others (Bassey and Harries 1993; Baskaran et al. 2010). The estimation of hand grip strength is of immense importance in determining the efficacy of different treatment strategies of the hand and also in the hand rehabilitation (Benefice and Malina 1996; Lad et al. 2013). The power of hand 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 (Charles and Burchfiel 2006; Baskaran et al. 2010). Evidence has shown that there were strong correlations between grip strength and various anthropometric traits, such as weight, height, hand length and BMI as had been reported earlier by Ross and Rosblad (2002) and Shyamal and Satinder (2011). In fact, the grip strength has been reported to be higher in dominant hand with right handed subjects, but there were no such significant differences between sides could be documented for left- handed people (Incel et al. 2006; Guerra et al. 2013). Right and left hand grip strengths were positively correlated with weight, height and body surface area in Indian population (Chatterjee and Chaudhuri 1991; Guerra et al. 2013; Flood et al. 2014).

The human hand is unique in being free of habitual locomotion duty and devoted entirely to functions of manipulation (Fess 1992; Moura-Dos-Santos et al. 2013). Its effectiveness in these activities is due to particular configuration of the bones and muscles which permits opposition of the pulp surface of the thumb to the corresponding surfaces of the other four finger tips in a firm grasp, together with a highly elaborated nervous control and sensitivity of the fingers (Dixon et al. 2005; Moura-Dos-Santos et al. 2013). The hand length and body height ratio, the shape index which determines hand shape, the digit index which determines grasping capability and the palmar length/width ratio which determines palmar type without the digits, and other anthropometric parameters are all important parameters to be considered when studying the grip strength in any population of interest as they all play roles

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in grip strength (Mathiowetz et al. 1986; McArdle et al. 2001; Spruit et al. 2013).

In the study of the relationships of hand grip strength 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 hand grip strength values than their female counterparts (Benefice and Malina 1996; Naeem et al. 2008; Montalcini et al. 2013). It has been shown that there was age dependent increase in hand grip strength in boys and girls as well as the inter-gender differences was strongly associated with changes of fat free mass during the childhood (Sartorio et al. 2002; Nicola et al. 2006; Prakash et al. 2011).

Handgrip strength (HGS) is a measure of strength of several muscles in the hand and the forearm (Bassey and Harrie 1991; Shyamal and Arvinder 2010). Hand grip strength is usually measured in either kilograms or Newtons depending on calibrations by squeezing a handgrip strength dynamometer with one's maximum strength. The power of grip is the result of forceful flexion of all finger joints with a maximal voluntary force that the subject is able to exert under normal biokinetic conditions (Navdeep and Shyamal 2010). Hand grip strength can be quantified by measuring the amount of static force that the hand can squeeze around a dynamometer. The force has most commonly been measured in kilograms and pounds, but also in millilitres of mercury and in Newtons (Newman et al. 1984; Snih et al. 2002).

Hand grip strength is a reliable measurement when standardised methods and calibrated equipment are used, even when there are different assessors or different brands of dynamometers (Mathiowetz 2002; Amit 2006). There are different methods of positioning patients during measurement, and for calculating their grip strength from repeated measures, so the American Society for Surgery of the Hand and the American Society of Hand Therapists have standardized positioning, instruction and calculation of grip strength (Fess 1992; Amit 2006; Prakash et al. 2011).

Hand grip strength is found to be a significant determinant of bone mineral content and bone area at the forearm sites and has a positive correlation with lean body mass and physical activity and determines the muscular strength of an individual (Foo 2007; Baskaran, et al. 2010). Hip and waist circumferences measurement are good markers of fat mass, bone mineral content and lean mass are strongly correlated with maximum isometric grip force (Rasid and Ahmed 2006; Prakash et al. 2011).

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).

Objective of the Study

The objective of the study was to evaluate the relationship between handgrip strength and other anthropometric variables namely height, weight, BMI, hand length, hand width, forearm length, arm length, and MUAC among Secondary School Students in Kano Nigeria.

MATERIAL AND METHODS

Study Population

A total of four hundred secondary school students of 14–18 years of age were randomly selected for the study from two different Secondary Schools in Kano Municipality, Kano State Nigeria. The study samples were made up of two hundred students from each of the schools comprising of one hundred males and one hundred females each. The schools are the Governor's College with 200 participating students, made up of one hundred (100) male students and one hundred (100) female students, and the First Grade Comprehensive School with 200 participating students, made up of one hundred (100) male students and one hundred (100) female students, making up the total of four hundred (400) students.

Study Area

Kano State is located in north-western Nigeria as part of former Northern Region and borders Katsina State to the north-west, Jigawa State to the north-east, Bauchi and Kaduna States to the south. It is indigenous to Hausa and Fulani tribes. Kano environment refers to the adminis-

trative area known as Kano State. It is so called because the State capital is named Kano. The Kano environment covers an area extending between latitudes 12^0 40' and 10^0 30' and longitude 7^0 40' and 9^0 30'.

The two schools selected for the study were the Governor's College, along Ibrahim Taiwo road, Kano and First Grade Comprehensive School on Lawal Dambazau link, Kano. All the participants were Hausas from Kano State.

Measurements and Data Collection

Body weights were measured using a standard scale with light clothing on, without any footwear. Heights were measured with each subject in upright position in front of a wall looking ahead and heels touching one another. BMI of the participants were calculated using the measurements of the weight in kilograms divided by the square of the height in meters (kg/m2). The hand lengths were measured using standard measuring tape in each subjects, defined as the distance between the mid-point of the distal wrist crease and the tip of the middle finger.

Mid Upper Arm Circumference (MUAC), is the circumference of the upper arm measured at the mid-point between the tip of the shoulder and the tip of the elbow, at the olecranon process and acromion.

Hand dynamometer made by Xinjing Sports, China, was used to measure the grip strength of the participants. Each participant was allowed to sit on a chair with the elbow flexed at 90 degrees and the forearm in semi- pronation lying on an arm rest. The participants were asked to squeeze the dynamometer with their hand and the grip strengths were recorded.

Statistical Analysis

Standard descriptive statistics (mean ± standard deviation) were determined for directly measured and derived variables. Pearson's correlation coefficients were used to establish the correlation of handgrip strength with other variables. A $P \leq 0.05$ probability level was used to indicate significance.

RESULTS

The result show the mean values for the age, height, weight, BMI, hand length, hand width, forearm length, hand width, forearm length, arm length, MUAC and handgrip strength (HGS) in the general population sample are 16.0±1.35yrs, 1.60±0.08m, 46.34±8.30kg, 18.02±2.81 kg/m^2, 19.34±0.98cm, 10.45±0.90cm, 27.93±1.92cm, 31.93±2.46cm, 24.37±2.27cm, 35.63±17.17 respectively as shown in Table 1.

Table 1: Descriptive Statistics for general samples (N=400)

Parameters	*Mean ± S.D.*	*Min-Max*
Age	16.00 ± 1.35	14 – 18
HT(m)	1.60 ± 0.076	1.39 – 1.83
WT(kg)	46.34 ± 8.30	22.00 – 89.00
BMI (kg/m²)	18.02 ± 2.81	9.40 – 30.10
HL (cm)	19.34 ± 0.98	16.50 – 22.00
HW (cm)	10.45 ± 0.90	8.50 – 12.00
FAL (cm)	27.93 ± 1.92	24.00 – 39.00
AL(cm)	31.93 ± 2.46	21.00 – 38.00
MUAC (cm)	24.37 ± 2.27	19.00 - 32.00
HGS (N)	35.63 ± 17.17	10.00 -102.00

N= total number, HT= Height, WT = Weight, BMI = Body Mass Index, HL = Hand length, HW = Hand Width, FAL = Forearm Length, AL = Arm Length, MUAC = Mid Upper Arm Circumference, HGS = Hand Grip Strength.

The descriptive statistics in both male and female students in each case showing the mean ± S.D., minimum and maximum values for each variable are as shown in Table 2. All the anthropometric variables studied were correlated to handgrip strength and also to each other to test for any relationship between the parameters as shown in Table 3. The results showed a positive correlation between handgrip strength and the anthropometric variables studied. While Tables 4 and 5 show the correlation matrix between the anthropometric variables and HGS in males and females respectively. The regression equations for HGS according to age are presented in Table 6.

DISCUSSION

The study of the relationship between handgrip strength and other anthropometric parameters was undertaken in four hundred Nigerian Secondary School Students of ages 14 to 18 years in Kano metropolis. The study correlated age and other anthropometric traits with handgrip of Students. The results revealed strong positive correlations between age, height and weight with handgrip strength in both males and

Table 2: Descriptive Statistics for male and female samples

	Males		*Females*	
Parameters	*Mean ± S.D. n = 200*	*Min.-Max.*	*Mean ± S.D. n = 200*	*Min.- Max*
AGE (yrs.)	16.42 ± 1.49	14 - 18	15.59 ± 1.05	14 - 18
HT (m)	1.64 ± 0.08	1.39 - 1.83	1.57 ± 0.054	1.44 - 1.72
WT (kg)	46.97 ± 8.29	28.0 - 89.0	45.70 ± 8.29	22.0 - 74.0
BMI (kg/m²)	17.45 ± 2.30	11.30 - 31.10	17.45 ± 2.30	9.40 - 28.90
HL (cm)	19.72 ± 1.01	17.0 - 22.0	18.95 ± 0.77	16.50 - 21.0
HW (cm)	10.85 ± 0.97	9.0 - 21.0	10.05 ± 0.61	8.50 - 12.0
FAL (cm)	28.58 ± 2.15	24.0 - 39.0	27.28 ± 1.39	24.0 - 31.30
AL (cm)	32.44 ± 2.65	21.0 - 38.0	31.41 ± 2.14	21.0 - 37.50
MUAC (cm)	24.23 ± 2.26	19.0 - 32.0	24.50 ± 2.26	20.0 - 32.0
HGS (N)	46.02 ±17.41	10.0 -102.0	25.23 ± 8.40	10.0 - 50.0

n= total number, HT = Height, WT = Weight, BMI = Body Mass Index, HL = Hand length, HW = Hand Width, FAL = Forearm Length, AL = Arm Length, MUAC = Mid Upper Arm Circumference, HGS = Hand Grip Strength.

Table 3: Correlation between the variables in male and female samples

	AGE	*HT*	*WT*	*BMI*	*HL*	*HW*	*FAL*	*AL*	*MUAC*	*HGS*
AGE	1									
HT	.431	1								
WT	.331	.485**	1							
BMI	.116*	-.045	.848**	1						
HL	.278	.646**	.398**	.073	1					
HW	.286**	.417**	.350**	.146**	.410**	1				
FAL	.256**	.631**	.317**	-0.19	.562**	.320**	1			
AL	.278**	.604**	.364**	.066	.481**	.320**	.485**	1		
MUAC	.280**	.180**	.796**	.807**	.197**	.293**	.120*	.208**	1	
HGS	.307**	.485**	.237**	-.026	.357**	.320**	.294**	.295**	.125*	1

** Correlation is significant at 0.01 level (2-tailed); n = 400
*Correlation is significant at 0.05 level (2-tailed)
HT = Height, WT = Weight, BMI = Body Mass Index, HL = Hand Length, HW = Hand Width, FAL = Forearm Length, AL = Arm Length, MUAC = Mid Upper Arm Circumference, HGS = Hand Grip Strength.

Table 4: Correlation between the variables in male samples

	AGE	*HT*	*WT*	*BMI*	*HL*	*HW*	*FAL*	*AL*	*MUAC*	*HGS*
AGE	1									
HT	.489**	1								
WT	.450**	.650**	1							
BMI	.250**	.163*	.851**	1						
HL	.291**	.637**	.415**	.111	1					
HW	.245**	.289**	.413**	.359**	.247**	1				
FAL	.285**	.601**	.378**	.080	.512**	.178****	1			
AL	.252**	.645**	.0404**	.100	.515**	.299**	.501**	1		
MUAC	.469**	.369**	.799**	.798**	.199**	.411**	.191**	.262**	1	
HGS	.516**	.430**	.568**	.463**	.341**	.314**	.276**	.334**	.626**	1

** Correlation is significant at 0.01 level (2-tailed); n = 200
*Correlation is significant at 0.05 level (2-tailed)
HT = Height, WT = Weight, BMI = Body Mass Index, HL = Hand Length, HW = Hand Width, FAL = Forearm Length, AL = Arm Length, MUAC = Mid Upper Arm Circumference, HGS = Hand Grip Strength.

Table 5: Correlation between the variables in female samples

	AGE	*HT*	*WT*	*BMI*	*HL*	*HW*	*FAL*	*AL*	*MUAC*	*HGS*
AGE	1									
HT	.45	1								
WT	.158*	.323**	1							
BMI	.149*	-.054	.926**	1						
HL	-.027	.441**	.394**	.243	1					
HBW	.297	.227**	.281**	.205**	.367**	1				
FAL	-.079	.498**	.224**	.032	.467**	.263**	1			
AL	.194**	.479**	.304**	.133	.328**	.187**	.359**	1		
MUAC	.104	.048	.811***	.840**	.302**	.296**	.095	.186**	1	
HGS	.167*	.172	.162*	.097	.151*	.151	.208**	.061	.124	1

** Correlation is significant at 0.01 level (2-tailed); n = 200
*Correlation is significant at 0.05 level (2-tailed)
HT = Height, WT = Weight, BMI = Body Mass Index, HL = Hand Length, HW = Hand Width, FAL = Forearm Length, AL = Arm Length, MUAC = Mid Upper Arm Circumference, HGS = Hand Grip Strength.

Table 6: Regression formulas for HGS according to age

	Age (Yrs)	*Male/Age (Yrs)*	*Female/Age (Yrs)*
HGS VS BMI	y = 0.6073x + 24.727	y = 1.5847x + 15. 326	y = 0.21x + 23.818
HGS VS HL	y = 7.9639x + 118.3	y = 7.798x - 108.79	y = 4.6463x - 61.179
HGS VS HW	y = 3.8076x - 4.4072	y = 2.2932x + 18.922	y = 6.2692x - 36.358
HGS VS FAL	y = 3.5877x - 64.516	y = 2.7611x - 34.638	y = 2.8184x - 49.843
HGS VS AL	y = 2.2822x - 37.178	y = 2.5403x - 38.685	y = 0.7198x + 5.0105
HGS VS MUAC	y = 2.3897x - 22.542	y = 3.8765x - 51.663	y = 0.5095x + 15.336
HGS VS HT	y = 120.66x - 157.67	y = 120.9x - 153.25	y = 54.448x - 58.172
HGS VS WT	y = 0.4373x + 15.399	y = 0.5081x + 21.861	y = 0.0132x + 24.654

HT=Height, WT=Weight, BMI=Body Mass Index, HL=Hand Length, HW=Hand Width, FAL=Forearm Length, AL=Arm Length, MUAC=Mid Upper Arm Circumference, HGS= Hand Grip Strength. y=dependant variable (HGS), x independent variable (age)

females. Sartorio et al. (2002) had reported that the age dependent increase of hand grip strength in males and females were strongly associated with changes of muscle mass during the childhood. The results from the present study are consistent with previous researches demonstrating stronger grip for men than women within the same age strata, and that hand grip strength decreases with advancement in age (Chatterjee and Chowdhuri 1991; Bohannon et al. 2006; Charles and Burchfiel 2006).

The results showed that Male Students showed higher mean values for all the tested anthropometric variables than females, except for BMI and MUAC where females had higher mean values. Based on the present study, males also showed a higher mean value for Hand grip strength and this agrees with the study conducted by Shyamal and Sartinder (2011), which showed that males have higher mean values of all the anthropometric parameters than females.

The present study has demonstrated that males are generally taller, heavier, and have longer hand length, hand width, forearm length, and arm length, with higher Hand grip Strength than their female counterparts. While females on the other hand, had higher BMI and MUAC than their male counterparts. This could either be as a result of females not involved in much physical activity as males do or 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; Flood et al. 2014). This is because, Sartorio et al. (2002) in their study had reported that age dependent increase of handgrip strength in boys and girls were strongly associated with changes of muscle mass during their childhood.

It was reported earlier that physical performance had a strong association with body strength, shape, size, form and structure of an individual (Ross and Rösblad 2002; Foo 2007; Guerra et al. 2013). The findings of the present study follow the same direction highlighting a highly significant positive correlation between all the anthropometric variables measured and handgrip strength both in males and females (Spruit et al. 2013; Flood et al. 2014).

It has been reported that as a rule, handgrip strength of both right and left hand dominant was stronger in males than females across all age groups (Newman et al. 1984; Mathiowetz et al. 1986; Naeem et al. 2008; Lad et al. 2013). The findings of the present study also followed the same direction in both male and female students. The Males have higher mean values in all the anthropometric variables than their female counterparts. 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; Montalcini et al. 2013).

In the case of height, a positive correlation with the hand grip strength could be as a result of different factors such as higher heights that would lead to longer arms, with greater lever of arm for higher force generation thus, resulting in an efficient amount of force. Similarly, Chatterjee and Chowdhuri (1991), Spruit et al. (2013) agreed that hand grip strength when measured by hand dynamometer was positively correlated with weight, height and body surface area.

When correlating HGS, in the general sample of males and females combined, with all the tested anthropometric variables, all the variables showed a strong positive correlation to Hand grip Strength. This was also shown to be true when the same correlation was made in male student samples only. But in female samples, however, the correlation only showed a positive relationship between hand grip strength and age, height, weight, hand length, forearm length while BMI, hand width, arm length, and MUAC showed no significant correlation. The regression formulae for predicting hand grip strength were obtained according to age in males and females and based on these findings, the present study was in agreement with the findings of the previous studies of Cagatay et al. (2011); Shyamal and Satinder (2011).

CONCLUSION

Based on the result of the present study, it could be concluded that all the tested anthropometric variables are positively correlated to Hand grip strength. It could also be concluded that male students are taller, heavier, have higher hand length, hand width, forearm length, and arm length than their female counterparts. This is because these variables are positively correlated to Hand grip strength, however, males showed a higher Hand grip strength than females.

RECOMMENDATIONS

From the result of the present studies it is highly recommended that further studies be conducted to evaluate the association between hand grip strength and body mass index (BMI), since the body mass index is a product of the body weight and height of the individual students. This will further give insight into the relationship between handgrip strength and general body well being as reflected by the BMI of the individual.

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