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Relationships between body somatotype and handgrip strength of young Nigerian undergraduate students

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Abstract

Background: Somatotype (SMT) is characterised by overall body adiposity, muscle mass distribution and strength. However, little is known about the connection between SMT and handgrip strength (HGS) in young healthy individuals. This study investigates the relationship between SMT and HGS among young Nigerian adults.

Methods: This cross-sectional study involved 385 (male: n=207, female: n=178) young adults of a Nigerian university using purposive sampling technique. Participants' physical characteristics were recorded while HGS was assessed using a digital dynamometer. SMT was classified as endomorph (ENM), mesomorph (MSM) and ectomorph (ECM) using the skinfold calliper measures and the Heath-Carter equations. Data were analysed using descriptive and inferential statistics. Alpha level was set at $p<0.05$.

Results: The means of age, body mass index and dominant (HGSD) of participants were 20.26±2.16 years, 19.81±1.95Kg/m² and 38.34±12.54 Kgf, respectively. The means of ENM, MSM and ECM were 3.98±1.14, 4.12±1.19, and 3.92±1.06, respectively. There were significant differences between male and female HGSD and non-dominant (HGSND); 47.66±8.77 and 27.50±5.64 Kgf (t=27.18; p=0.010) and 42.58±6.63 and 22.87±3.80 Kgf (t=36.39; p=0.010), respectively. There were significant inverse correlations between ENM and each of HGSD (r=-0.60; p=0.001) and HGSND (r=-0.70; p=0.001). Similarly, significant inverse correlation existed between ECM and each of HGSD (r=-0.38; p=0.001) and HGSND (r=-0.31; p=0.001). However, there were significant positive correlations between MSM and each of HGSD (r=0.45; p=0.001) and HGSND (r=0.39; p=0.001).

Conclusion: Body somatotype appears to influence the degree of handgrip strength among healthy Nigerian undergraduate students. Mesomorphs and ectomorphs have higher handgrip strengths than endomorphs.

Key words: somatotype, body composition, undergraduate student, young adult

Introduction

Human physique comes in different shapes and shades depending on body composition and nature of muscle mass in the body which can be described as the relative amount of body constituents such as fat, water and muscles [1]. Body composition may also depict body size describing the physical magnitude of the body in terms of its volume, mass, length and surface area. Additionally, categorisation of body size may be described as short or tall, large or small, heavy or light while visual appraisal of body build often describe individual as thin, muscular or fat [1, 2]. These descriptions of body composition and muscle mass relative to body size is referred to as body somatotype grouping which has been identified as a way of quantifying human body physique.

Somatotype is frequently used to provide information about three different components including endomorph, connected with share of adipose tissue, mesomorph, relating to muscle mass and ectomorph expressed in relationship to body weight and height [2, 3]. Somatotype assessment may be used to describe changes in the human physique over lifespan or as a result of physical activity participation [4]. Somatotype may also help to provide synthetic information about body build and its relationship with motor capabilities or physical performance [2, 5]. Physical performance depends on body's ability to recruit required fine motor nerve and muscle fibres in order to generate adequate muscular forces. It is unclear whether body tissue adiposity interferes with the generation of muscular forces of the musculoskeletal system. Interestingly, muscular strength is considered as one of the determining factors of the health status based on handgrip strength (HGS) assessment [6].

Regular assessment of HGS could be used in the clinical setting to determine the extent of injury or disease process and the potential for progress of individual during rehabilitation [6 - 8]. It could help to establish a baseline or guideline for a treatment program and also acts as a measure to decide the effectiveness of the therapy [9, 10]. Literature corroborates that HGS is an objective test for physical capability [11,12]. It refers to the ability of muscle or group of muscles to exert or generate maximal voluntary force in relation to motor fitness and total body strength [8, 13]. In addition, there is a large quantity of data indicating a high preponderance of poor HGS among women compared with men in health and disease [14,15]. However, it is not known whether differences in body adiposity or somatotype between men and women contribute to the disparity in HGS.

Despite the fact that there is increasing prevalence of obesity and high incidence of many chronic non-communicable diseases (NCDs), few studies have been carried out to objectively explore the relationship between somatotype, body composition and generation of maximal voluntary force for determining the degree of HGS in health young adults. Although several factors may affect HGS performance including but not limited to sex, age, height, weight, handedness, hand dimensions, extrinsic and intrinsic muscles of the hand and hereditary [16,17], information on the influence of somatotype on HGS still remains scarce.

Assessment of upper extremity, hand function and general strength as well as body composition and somatotype could serve as a pointer to or predictor for risk of developing chronic NCDs in future. Previously, HGS has been used as predictor of disability and mortality in the elderly [18]. Earlier, HGS has been correlated with some anthropometric measures, disease progression, nutritional status and overall physical function [19,20]. However, there appears to be dearth of empirical data relating somatotype and HGS among apparently healthy adults. The objective of this study was to investigate the relationship between body somatotype and HGS of young Nigerian undergraduate students.

Materials and Methods

Participants and study design

Participants for this study were undergraduate students of the Obafemi Awolowo University (O.A.U), Ile-Ife, Osun State, Nigeria. This cross-sectional study design employed purposive sampling to select the participants. Eligibility for inclusion was apparently healthy undergraduate students whose ages ranged between 18 - 35 years and with not known history of orthopaedic or neurologic defect to the upper limbs. Participants that involved in regular sporting activities or any form of paramilitary trainings were excluded from the study. This study was conducted at the Department of Medical Rehabilitation, College of Health Sciences, Obafemi Awolowo University (O.A.U), Ile-Ife, Osun State, Nigeria. The sample size for this study was based on the sample size formula for proportions with population greater than 10,000 [21]. As at 2015, the Directorate of Students' Affairs of OAU estimated the population of undergraduate students to be 30,000 [22]. In order to estimate an appropriate sample size for this study, a proportion of 50% of the population with 95% confidence interval (z = 1.96) and an absolute standard error (d = 0.05) while 50% was used (0.50) and (q = 1 - p = 0.05). Hence, a sample size of 384 participants was estimated for this study.

Procedure

Prior to the commencement of this study, ethical approval for this study was obtained from the Human Research and Ethics Committee (HREC: IPH/OAU/12/949) of the Institute of Public Health, College of Health Sciences, Obafemi Awolowo University, Ile-Ife, Nigeria. This was with the view to ensuring that the research protocol is compatible with the Declaration of Helsinki. The purpose and procedures of the study were explained to each participant. Furthermore, informed consent of participants who volunteered to participate in the study was obtained.

Assessment of anthropometric characteristics

Stature (height): Standing height was taken against a stadiometer (Seca Mod. 220, Germany). The participant stands straight with the heels, buttocks and back touching against the stadiometer. The upper border of the ear opening and the lower border of the eye socket on a horizontal line while the heels were together. Participant was instructed to stretch upward and to take and hold a full breath. The headboard was lowered until it firmly touched the vertex of the head.

Body mass (weight): The participant wearing minimal clothing and stood in the centre of the weighing scale (OMRON: HN - 286- E, Digital weighing balance, Australia). The weight was recorded to the nearest kilogram.

Assessment of body composition skinfolds

Ten anthropometric dimensions were taken to calculate the anthropometric somatotype; stretch stature, body mass, four skinfolds (Triceps, Subscapular, Supraspinale, and Medial Calf), two bone breaths (biepicondylar humerus and femur), and two limb girths (arm flexed and tensed calf). Procedures for the descriptions of body composition skinfolds were adapted from the work of Carter and Heath, [23]. A fold of skin and subcutaneous tissue was raised firmly between thumb and forefinger of the left hand and away from the underlying muscle at the site to be measured. The edge of the plates on the calliper (Lange skinfold calliper, PAT NO: 3.008 239, Maryland, USA) was allowed to branch up to 1 cm below the fingers of the left hand. They were allowed to exert their full pressure before reading the thickness of the fold. All skinfolds were taken on the right side of the body of participants. Participant in standing position relaxed, except for the calf skinfold which was taken with the participant seated.

Triceps skinfold: With the participant's arm hanging loosely in the anatomical position, a fold was raised at the back of the upper arm at a level halfway on a line connecting the acromion and the olecranon processes.

Subscapular skinfold: The subscapular skinfold was raised on a line from the inferior angle of the scapula in a direction that is obliquely downwards and laterally at 45 degrees.

Supraspinale skinfold: The fold was raised 5 - 7 cm (depending on the size of the participant) above the anterior superior iliac spine on a line to the anterior axillary border and on a diagonal line going downwards and medially at 45 degrees. This skinfold was formerly called suprailiac, or anterior suprailiac. The name has been changed to distinguish it from other skinfolds called "suprailiac", but taken at different locations.

Medial calf skinfold: A vertical skinfold on the medial side of the leg was raised at the level of the maximum girth of the calf.

Biepicondylar breadth of the humerus: The width between the medial and lateral epicondyles of the humerus was assessed with a Vernier calliper (Mitutoyo, GQ-638, U.S.A) was used to measure the biepicondylar breadth of the humerus. The calliper was applied at an angle approximately bisecting the angle of the elbow with the shoulder and elbow flexed to 90 degrees. Firm pressure was placed on the crossbars in order to compress the subcutaneous tissue. Similarly, the bi-epicondylar breadth of the femur was measured with participant seated and knee flexed at right angle. The greatest distance between the lateral and medial epicondyles of the femur was measured with firm pressure on the crossbars in order to compress the subcutaneous tissue. *Muscle girth:* A non-elastic tape measure (Butterfly; 60 inches, 150cm long, 0.7cm width, Japan) was used to measure muscle girth.

Upper arm girth: Participant flexed the shoulder to 90 degrees and the elbow to 45 degrees, clenched the hand, and maximally contracted the elbow flexors and extensors. The measurement was taken at the greatest girth of the arm [23].

Calf girth: Participant stood with feet slightly apart; the tape was placed around the calf and the maximum circumference was measured [23].

Assessment of somatotype rating

The Heath-Carter Anthropometric Somatotype Instruction Manual (2002) guidelines were used to obtain the body somatotype of each participant. A somatotype rating involves a combination of an anthropometric rating as described by Carter and Heath [23] was used. The procedure employed information of four skinfold measurements involving triceps, subscapular, supraspinale and medial calf muscles. Statures and body weight, bone breadths (biepicondylar breadth of humerus and femur) and limb girths (flexed biceps and tensed calf muscles) were also measured to compute the somatotype rating. The stature and girth were recorded to the nearest 1.0 cm, biepicondylar breadths to the nearest 0.1cm and the skinfolds to the nearest 1mm. All measurements were taken on the right side of the participants. The data obtained from the various sites were entered into the following derived equations as stated by Carter & Heath, [2].

$$\textit{Endomorph} = - 0.7182 + 0.1451 (X) - 0.00068 (X^2) + 0.0000014 (X^3)$$

Where X = (sum of triceps, subscapular and supraspinale skinfolds) multiplied by (170.18/ height in cm). This is called height-corrected endomorph and is the preferred method for calculating endomorph.

Mesomorph = 0.858 x humerus breadth + 0.601 x femur breadth + 0.188 x corrected arm girth + 0.161 x corrected calf girth – height 0.131 + 4.5.

Three different equations are used to calculate ectomorph according to the height-weight ratio, where the $HWR = Height/\sqrt[3]{Weight}$ $HWR = Height/\sqrt[3]{Weight}$

If HWR is greater than or equal to 40.75 then *Ectomorph* = 0.732 HWR - 28.58

If HWR is less than 40.75 but greater than 38.25, then *Ectomorph* = 0.463 HWR - 17.63. However, if HWR is equal to or less than 38.25, then *Ectomorph* = 0.1 [2].

Assessment of handgrip strength

A brief interview preceded the determination of the muscular strength to determine the participants' dominant hand and to screen individuals with previous hand injury. Each participant's hand grip strength (HGS) was assessed using an electronic hand dynamometer (Camry Model EH 101, Taiwan) based on the recommendation of the American Society of Hand Therapist [24]. Participant sat on a straight-back armless chair of standard height. Participant's test arm was held at 90° elbow flexion position with the forearm in neutral position preventing radio-ulnar deviation. The hand was positioned parallel to the forearm holding the dynamometer. Participant was instructed to squeeze maximally and hold until the reading is taken [25]. Two measurements were taken for each upper extremity at 2-minutes rest interval; the average was recorded in kilogram-force (Kgf) as grip strength value. For standardisation, the dynamometer was set at the second handle position. No verbal encouragement was given.

Data analyses

Data were analysed using descriptive statistics of frequency, percentage, mean and standard deviation. Independent t-test was used to compare body somatotypes, handgrip strength, dominant and the non-dominant hand between the male and female participants. Pearson's Product Moment Correlation was used to determine the relationship between body somatotypes, anthropometric characteristics and handgrip strength. Alpha level was set at $p<0.05$. Statistical Package for Social Sciences (SPSS) version 20 was used for data analysis.

Results

Table 1 shows the mean age and physical characteristics of participants. A total of 385 (males: n=207, females: n=178) young adults participated in this study. The mean age of participants was 20.26 ± 2.16 years. Participants were comparable in age and body mass indices ($P<0.05$), but not in height and weight ($p> 0.05$).

Table 2 shows the comparison of body somatotype and handgrip strength between male and female participants. The means of body somatotype of male and female participants were; endomorph: 3.11 ± 0.66 vs. 4.99 ± 0.65, mesomorph: 4.42 ± 1.02 vs. 3.78 ± 1.28 and ectomorph: 3.67 ± 1.01 vs. 4.21 ± 1.05, respectively. There was no significant difference between male and female participants in the three body somatotype groupings ($p > 0.05$). However, comparison of male and female dominant and non-dominant HGS showed significant difference; HGSD: 47.66 ± 8.77 vs. 27.50 ± 5.64 Kgf ($t = 27.18$; $p = 0.010$) and HGDND: 42.58 ± 6.63 vs. 22.87 ± 3.80 Kgf ($t =36.39$; $p = 0.010$), respectively.

Table 1: Comparison of age and physical characteristics between male and female participants

Variable	All(n=385) Mean ± S.D	Male (n=207) Mean ± S.D	Female (n=178) Mean ± S.D	t-cal.	p-value
Age (yrs)	20.26 ± 2.16	20.90 ± 2.27	19.51 ± 1.75	1.688	0.382
Weight (kg)	59.02 ± 7.43	63.31 ± 6.48	54.02 ± 4.92	-2.426	0.038*
Height (cm)	172.42 ± 5.67	175.29 ± 5.43	169.07 ± 3.79	1.842	0.049*
BMI (kg/m²)	19.81 ± 1.95	20.60 ± 1.81	18.91 ± 1.70	1.745	0.052

*p < 0.05
Key: BMI: Body mass index; S.D: Standard deviation

Table 2: Comparison of body somatotype and handgrip strength between male and female participants

Variable	All (n=385) Mean ± S.D	Male (n=207) Mean ± S.D	Female (n=178) Mean ± S.D	t-cal.	p-value
Endomorph	3.98 ± 1.14	3.11 ± 0.66	4.99 ± 0.65	-28.10	0.300
Mesomorph	4.12 ± 1.19	4.42 ± 1.02	3.78 ± 1.28	5.40	0.080
Ectomorph	3.92 ± 1.06	3.67 ± 1.01	4.21 ± 1.05	-5.14	0.430
HGSD (Kgf)	38.34 ± 12.54	47.66 ± 8.77	27.50 ± 5.64	27.18	0.010*
HGSND (Kgf)	33.47 ± 11.27	42.58 ± 6.63	22.87 ± 3.80	36.39	0.010*

*p < 0.05
Key: HGSD: Dominant handgrip strength; HGSND: Non-dominant handgrip strength; S.D: Standard deviation

The correlation between anthropometric characteristics, body somatotype and handgrip strength is presented in Table 3. The results show that BMI has significant positive correlation with mesomorph (r = 0.63; p = 0.001) but significant inverse correlation with ectomorph (r = 0.94; p = 0.001). Furthermore, there were significant inverse correlations between endomorph and dominant HGS (r = -0.60; p = 0.001) and non-dominant HGS (r = -0.70; p = 0.001). However, there were significant positive correlation between mesomorph and dominant HGS (r = 0.45; p = 0.001) and mesomorph and non-dominant HGS (r = 0.39; p = 0.001). Contrarily, there was significant negative correlation between ectomorph and dominant HGS (r = -0.34; p = 0.001) and ectomorph and non-dominant HGS (r =-0.31; p = 0.001).

Discussion

This study assessed the body somatotypes, dominant and non-dominant handgrip strength (HGS) and their relationships among young Nigerian university undergraduates. The results of this study indicated that the HGS of males in both dominant and non-dominant hands were significantly higher than of the females. These results were consistent with the findings of previous studies in which males were found to have higher grip strengths than females [7, 26]. One possible explanation for these differences could be due to the nature of activity being engaged by males compared to females. For example, males are more active in intense activities such as weight training, which cause greater hypertrophy of the muscles whereas females are more active in endurance type activities such as aerobics, where the hypertrophy is not as great [27, 28]. Moreover, the difference in gender grip strengths could be attributed to female ~~gender's~~ physique. Males on the average have greater lean body mass (more muscle) which is a major determinant of strength; hence, it is possible for male to have greater HGS. More importantly, differences in hormonal composition between males and females may be the main reason for higher muscle mass in males than females. This study also indicates that HGS of the dominant hand is higher than that of non-dominant hand. These findings are consistent with the findings of previous studies that dominant hand demonstrated higher strength than the non-dominant hand [29, 30].

It is not surprising that dominant hand has higher HGS than non-dominant hand because regular uses of particular limb encourages simultaneous higher recruitment of fine motor nerve fibres, thus resulting to greater hypertrophy of the muscles concerned and subsequently bring about higher strength and HGS. Similarly, limb dominance may be greatly influenced by higher

Table 3: Relationship between age, anthropometric characteristics, body somatotype and handgrip strength

Variable		Age	Weight	Height	BMI	Endomorph	Mesomorph	Ectomorph	HGSD	HGSND
Age (years)	(r)	1								
Weight (Kg)	(r)	0.52**	1							
Height (cm)	(r)	0.32**	0.64**	1						
BMI (kg/m²)	(r)	0.45**	0.85**	0.14**	1					
Endomorph	(r)	-0.17**	-0.28**	-0.49**	-0.02	1				
Mesomorph	(r)	0.17**	0.04**	-0.10	0.63**	-0.01	1			
Ectomorph	(r)	-0.34**	-0.64**	0.18**	-0.94**	-0.14**	-0.65**	1		
HGSD (Kgf)	(r)	0.43**	0.68**	0.53**	0.51**	-0.60**	0.45**	-0.38**	1	
HGSND (Kgf)	(r)	0.41**	0.67**	0.55**	0.49**	-0.70**	0.39**	-0.31**	0.93**	1

*p<0.05, **p<0.001
Keys: BMI: Body mass index; HGSD: Dominant handgrip strength; HGSND: Non-dominant handgrip strength; r = Pearson's correlation

centre in the brain, thus, contributing to better volitional forces of HGS.

Findings from this study also indicated that some selected anthropometric characteristics showed significant positive relationship with HGS. Interestingly, body weight, height and body mass index had significant positive relationships with HGS. This result is consistent with the findings of previous studies indicating that body compositions is related to muscle mass and distribution of fat deposit in human [31,32]. It is also possible that height is more closely related to lean body mass and stature. In addition, findings from this study also describe different body somatotypes in relation to measured body composition, anthropometric measures and standard equations developed by Carter and Heath [2]. Considering the mean values of different body somatotypes (endomorph, mesomorph and ectomorph) found in this study, it appears that these values are similar to that of previous studies [3,33]. It is possible that participants in our study shared some physical similarities with that of previous studies. Surprisingly, findings from this study show that body somatotypes as regards endomorph and ectomorph indicated significant inverse relationships with HGS. This is contrary to the findings of a previous study which reported positive relationship between endomorph, ectomorph and HGS [33]. The plausible reason for the difference may be related to the age category of participants in their study. On the other hand, findings from this study showed that there is significant positive relationship between mesomorph and HGS. This is consistent with the finding of Saha, [33]. The possible reason for the finding could be that all participants in their study were all male subjects with more muscle mass and subsequently categorized as mesomorphs.

There is little doubt that variations in human anatomical structures could influence certain differences. Findings from this study indicated that endomorph which expresses the degree of adiposity development is greater in females than in males whereas mesomorph which reflects muscle development known to be positively associated with strength and motor performance in general is greater in males than females [34,35]. Similarly, ectomorph is more common in males than the female counterparts. These findings are consistent with the findings of previous studies that mesomorph is associated with males while endomorph is related to female body shapes [5,36]. A possible explanation for these findings may be due to the increased fat content in females for endomorph and increased muscular development in males for mesomorph. The differences in the body somatotype as regards ectomorph may be due to the fact that participants in our study were mainly young undergraduate students (non - athletes) with reduced muscle mass, low fat deposit and participation in sporting activities is somewhat limited whereas participants in Saha's study were largely young athletes with greater muscle mass.

It is noteworthy that there were some limitations in this study. This is a cross-sectional study and causal relationship could not be established which may limit the generalisability of these findings to other populations. More importantly, our participants are university undergraduates and they may not be considered as true representative of Nigerian adults who engage regularly in manual work or elite sports. Furthermore, assessment methods we used to categorise our participants into different body somatotypes may vary from other young adults due to racial variations, methodological issues and environmental factors. Nonetheless, the validated equations for body somatotype and strict adherence to methods of assessing body compositions appear to limit bias of our results.

Conclusions

Body somatotype appears to influence the extent of handgrip strength among healthy young Nigerian adults. Mesomorphs and ectomorphs have higher handgrip strengths than endomorphs. Furthermore, dominant handgrip strength is stronger than the non-dominant hand. Findings from this study have implications for understanding the influence of somatotype on handgrip strength with the view to designing appropriate rehabilitation regimens for young adults with altered body somatotype due to rapid growth, changes in dietary pattern or injury.

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Conflict of Interest

The authors declared none.

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