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Association of grip strength with anthropometric measures: Height, forearm diameter, and middle finger length in young adults

Ukachukwu Okoroafor Abaraogu *, *Charles Ikechukwu Ezema*, *Uche Nelson Ofodile*, *Sylvester Emeka Igwe*

Department of Medical Rehabilitation, University of Nigeria, Enugu, Nigeria

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ABSTRACT

Introduction: Grip strength is routinely utilized in wide range of clinical setting as a physiological variable that is affected by a number of factors.
Aim: We examined the relationships of forearm circumference, middle finger length, height, and BMI with handgrip strength measured among a group of young adults.
Material and methods: This is a cross-sectional design among 517 young adults. Data was collected on one occasion using a hand held dynamometer for grip strength of dominant and non-dominant hands, commercial-scale for weight; tape measure for height, self report for age and gender.
Results and discussion: Forearm circumference, middle finger length and height showed significant positive correlation ($P < 0.01$) with grip strength across both the dominant and non-dominant limb. On the other hand, there was no significant correlation between BMI and grip strength for both limbs ($P > 0.05$).
Conclusions: In determining age and gender specific nomogram as well as assessing intervention outcomes for handgrip strength in young adults, anthropometrics of forearm circumference, middle finger length and height should be considered.

1. Introduction

Handgrip strength may be an indicator of muscular strength of an individual,[1,2] and is usually explored as a functional index of physical health.[2–7] Because of its close association with the neural and musculoskeletal systems, grip strength is routinely utilized in wide range of clinical settings including evaluation of individuals with pathologies affecting the upper limb function. It is also important in determining the efficacy of different treatment strategies in hand rehabilitation.[8]

* *Correspondence to*: Department of Medical Rehabilitation, Faculty of Health Science and Technology College of Medicine, University of Nigeria, Enugu 400006, Nigeria. Tel.: +234 806 358 2105.
E-mail address: ukachukwu.abaraogu@unn.edu.ng (U.O. Abaraogu).

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As handgrip data is one of the important outcomes in certain patient populations, there is increasing interest in establishing normal values for handgrip strength. However, handgrip strength is a physiological variable affected by a number of factors. Most normative values did not include important anthropometrics which could introduce variation in handgrip strength among people of the same age and gender. For instance, differing BMI in individuals of the same age and gender could mediate differences in outcome of certain characteristics including strength. Similarly, both middle finger length and forearm diameter showed wide variation among individual of the same age and sex. However, relationship between middle finger length and forearm diameter and handgrip strength has remained largely understudied. Consideration of the hand dimension, including the middle finger is important from a biomechanical point of view. First the middle finger is usually the longest finger, and the length of the fingers weighs on the mechanical advantage of the hand in grasping tasks. Specifically, a longer middle finger will provide more surface variables required for grasping an object. This reduces the need to spread the digits wider, results to better ankle of pull, more biomechanical efficiency and less fatiguing.[9] Accordingly, there is the question of comprehensiveness of the available handgrip reference values and accurate prediction of handgrip strength considering all possible predictors.

To identify studies on grip strength among young adults, we searched data bases – Medline, Embase, as well as gray literature utilizing a combination of keywords including young 'adults,' 'grip strength,' 'dynamometer,' 'anthropometrics,' 'BMI,' 'middle finger length,' 'forearm diameter.' Additionally, reference lists were further searched to identify possible articles that may not have appeared in earlier search. Many of these articles did not include sufficient anthropometric variables notably middle finger length, and forearm diameter as correlates when reference values were being drawn up. It is important to assess relationships between middle finger length, forearm diameter and grip strength in young adults to guide decision regarding their possible inclusion in predictive equation for age- and gender-specific normal values of grip strength this group. Also many earlier studies either did not differentiate between dominant and non-dominant score, used instrument that is now obsolete, or scored maximum instead of mean of scores of repeated evaluations.

According to Kisner and Colby,[10] the age group when individuals develop maximum muscle mass is 18–25 years. Establishing a comprehensive and an inclusive reference values among this group is important since much of muscle mass and strength is less likely to decline until much later after middle age.[11,12] An empirical data that establishes evidence of significant influence of handgrip strength by these anthropometrics is needed, before strong argument is made for their consideration and inclusion in future report on handgrip normal values.

2. Aim

The aim of this study is to investigate relationship of grip strength with BMI, height, forearm diameter, and middle finger length among young adults aged 18–25 years old.

3. Material and methods

3.1. Design

The study utilized a cross-sectional descriptive design among 517 young adults.

3.2. Participants

Participants were comprised of apparently healthy male and female undergraduate and postgraduate students of University of Nigeria aged 18–25 years. The aim was to include a near equal representation of male and female as well as age group within the study. The exclusion criteria were ambidexterity, hand deformity e.g. aneuploidy, pain in the hand, sensory abnormality, restricted movement of upper limb, any injury to the upper limb, diagnosed generalized bone disease, hypertension or diagnosed cardiac condition, or any condition that interfered with instruction on how to use dynamometer.

3.3. Procedure

Ethical approval for the study was received from the Research and Ethics Committee of the University of Nigeria Teaching Hospital, Ituku-Ozalla, Enugu. Also, all participants completed a voluntary written informed consent form for the study.

Before the study, participants were assessed using physical activity readiness questionnaire (PAR-Q)[13] while blood pressure was evaluated to delimit those who had the risk of cardiovascular events. Como grip strength dynamometer (Xinjing Sports Company, China) was used to obtain the handgrip strength of the subjects to the nearest 1 kg. Tape measure (Butterfly 60 inch/150 cm tape, Shanghai, China) was used for measuring the middle finger length and the forearm circumference to the nearest 0.1 cm. Stadiometer (Holtain, Crymych, Dyfed, UK) was used to measure the height of the subjects to the nearest 0.1 cm while a weighing scale (Hana Bathroom Scale, China) was used to measure the weight of the subjects to the nearest 0.1 kg. Sphygmomanometer (Accoson, UK) was used to measure the blood pressure of the subjects to rule out high blood pressure.

Forearm circumference was measured from 12 cm distal to the olecranon process in a flexed elbow at 90°. The tape was applied closely to the skin but without causing compression.[14] Middle finder length was measured from the tip of the middle finger to its proximal digit crease. Measurements were taken from the palmar side while digits were fully stretched and rested on a flat and hard surface with the 2nd and 5th digits abducted and thumb slightly extended.

The grip strength of both right and left hands was measured using a handgrip dynamometer according to the American Hand Therapist standardized arm position for handgrip testing. Each subject was positioned in a straight back chair (with an arm rest) with both feet on the floor. The arm position was demonstrated to the subjects. Each subject was asked to rest the arm to be measured on the ipsilateral thigh and to maintain a posture with shoulder adducted and neutrally rotated, elbow flexed by approximately 90° flexion, forearm and wrist in neutral position, and fingers flexed for the

needed maximum contraction. Participants were instructed to keep the trunk in neutral position (and not lean forward), to avoid pressing the forearm on the quadriceps. They were instructed to breathe in through the nose and exhale through a pursed lip after a maximum grip effort was made. A demonstration of the maximum grip effort was shown to each subject before they were asked to do it. The period of effort did not exceed 5 s. Then the subjects were instructed to squeeze the dynamometer as tightly as possible, using the musculature of the hand. No part of the subject's upper or lower arm or hand was allowed to push against any object or against any other part of the body. The force exerted was read from the dial of the dynamometer in kilograms and the average value was recorded, after three successful attempts on each hand with one-minute rest between trials. All anthropometric equipment was calibrated before the assessment.[15] Maintenance schedules were conducted for calibration of dynamometers after 25 completed assessments.

3.4. *Data analysis*

The data obtained was presented in mean and standard deviations. Pearson's correlation coefficient was used for correlation test for relationship between anthropometrics and handgrip strength. Data was analyzed using SPSS (Statistical Package for Social Science) v. 15.0 with level of significance set at 0.05.

4. Results

A total of 517 young adults (18–25 years) were involved in the study with 280 male and 237 female having mean ages of 25.01 ± 6.34 and 24.71 ± 82, respectively. Their mean handgrip strength was 51.73 ± 13.03 in the dominant and 44.09 ± 14.99 in the non-dominant limb. The female group had lower mean grip strength for both limbs when compared with the male (Table 1).

Table 1 – Participants characteristics.

Gender	*n* (%)	*P* value
Male	280 (54.16%)	
Female	237 (45.84%)	
Anthropometrics		
Age, y	24.75 ± 5.25	
Height, m	1.71 ± 0.76	
Weight, kg	65.80 ± 9.56	
BMI, kg/m^2	22.57 ± 3.30	
Forearm circumference, cm	25.34 ± 2.46	
Middle finger length, cm	8.26 ± 0.74	
Grip strength by gender groups		
Dominant limb		
Male	64.64 ± 13.04	<0.001
Female	38.83 ± 13.01	
Non-dominant limb		
Male	58.45 ± 17.25	
Female	29.73 ± 12.74	<0.001
Grip strength by limb dominance		
Dominant	51.73 ± 13.03	
Non-dominant	44.09 ± 14.99	0.024

Table 2 – Correlation between anthropometrics and grip strength.

	Pearson correlation	*P* value
Forearm circumference		
Dominant limb	0.634	<0.001
Non-dominant limb	0.680	<0.001
Middle finger length		
Dominant limb	0.441	<0.001
Non-dominant limb	0.433	<0.001
Height		
Dominant limb	0.548	<0.001
Non-dominant limb	0.475	<0.001
BMI		
Dominant limb	−0.039	0.258
Non-dominant limb	−0.012	0.420

The relationship between anthropometrics and grip strength in terms of Pearson correlation are shown in Table 2. Forearm circumference, middle finger length and height showed significant positive correlation ($P < 0.001$) with grip strength across both the dominant and non-dominant limb. On the other hand, there were no significant correlation between BMI and grip strength across the two upper limbs ($P > 0.05$).

5. Discussion

In this study the grip strength of 517 participants (280 male and 237 female) of mean age 24.75 ± 5.25 years were evaluated using a hand held grip dynamometer to investigate relationship between grip and anthropometric parameters including forearm circumference, height, BMI, and middle finger length. The mean handgrip strength in our study participants were 54.26 kg and 46.90 kg for the dominant and non dominant limbs, respectively. The mean grip strengths of both hands in the males were higher than the female which is consistent with previous findings[16–18] indicating that men are consistently stronger than women. The percentage lean body mass, a major determinant of strength is higher in male than female, and could the observed higher grip strength in males. The dominant limb was significantly stronger than the non-dominant limb regardless of gender. This agrees with findings of Bansal,[19] Glad-Mohesh and Jaiganah,[20] and Adedoyin et al.[18] Importantly Clarke and Clarke[21] had stated the need of distinguishing the dominant and non-dominant limbs in study of grip strength. However result in only a few studies was presented with respect to hand dominance while that in other studies were presented with respect to laterality (right and left hand). In our study, we attempted to delineate differences in handgrip in terms of dominant and non-dominant limbs.

Forearm circumference was significantly correlated with handgrip strength and individual with higher forearm diameter showed consistently higher grip strength across both limbs. Fallahi and Jadidian[22] observed similar finding in non-athletes. The correlation between forearm girth and handgrip strength may be explained by the influence of the fiber diameter of the flexor digitorum sublimis on the flexion contractile ability of the hand.

Our finding is that the middle finger length positively correlates with handgrip strength in young adults contrasting earlier finding by Fallahi and Jadidian[22] who found no correlation between handgrip and middle finger of athletes. The difference between our findings and that of Fallahi and Jadidian[22] could be explained by the fact that advantage of athletic training in their subjects may have halted possible correlation that existed between grip and middle finger length. Furthermore athletes involved in Fallahi and Jadidian study had longer middle finger length raising another question if middle finger relationship with grip strength is attenuated at certain length above which relationship does not exist. Our sample specifically consisted of non-athletes non-involved in physical activity or job that could confer advantage to their grip strength and showed that middle finger length may influence strength conferring biomechanical advantage of increase strength to those with longer middle finger. Interestingly positive correlation between middle finger length and grip strength has earlier been reported by Nicolay and Walker however among 51 college students.[23] However, their sample size was considerably low and not based on any scientific sample size calculation and rendering the validity of finding to low internal validity.

Positive correlation was seen between height and grip strength among the young adults. Several studies have reported positive correlation between height and handgrip strength across adult to elderly population. This is the first study that reported relationship with height with sample of young adults. Fallahi and Jadidian's finding did not show correlation between height and grip strength in athletes.[22] Although we did not include athletes and therefore could not make statement regarding height grip relationship among athletes, our study is similar to that of Fallahi and Jadidian in that both documented grip strength among young adults and had defined group of non-athletes. The difference in our finding could be partly explained by the utilization of appropriate sample size unlike Fallahi and Jadidian who involved only 40 non-athletes.

BMI did not correlate with handgrip strength in our sample. Finding on relationship between BMI and handgrip strength varies in literature. Fallahi and Jadidian, Kamarul et al., and Günther et al. all reported that BMI does not influence handgrip strength.[22–25] Mitsionis et al. however reported association between BMI and dominant handgrip strength only in females,[26] whereas reported correction of BMI with handgrip strength of persons 6–25 year. Putting the contrasting results together, the common ground is that BMI is not correlated with non-dominant handgrip strength among females as seen in Adedoyin et al., Mitsionis et al. and our present study. The disparity of correlation reported among our study, Adedoyin et al.[18] and Mitsionis et al.[26] could be related to the difference in age range used in these three studies. Similarly, Koley et al.[27] included children, adolescents and adults in their study making it difficult to isolate the influence of BMI from result derived sample comprising different age groups. Therefore age influence on handgrip may have contaminated their findings. Specifically, from our study BMI did not correlate with grip strength of both the dominant and non-dominant hands of the young adults.

We studied handgrip strength and its correlation to BMI, height, forearm circumference and middle finger length among young adults by establishing the mean of three attempts of grip strength testing. The major limitation of our study is the direct implication of the exclusion criteria, implying that results can only been applicable to the healthy population and among young adults within the age group studied. Furthermore, only BMI as index of peripheral adiposity was used in this study. It is suggested that future studies should investigate possible correlation with central adipose measures like lean body mass.

6. Conclusions

Classification of age- and gender-specific normal values for grip strength, as well as assessing intervention outcomes in pathologies impacting on handgrip strength in young adults, should consider factors of forearm circumference, middle finger length and height. Also central adipose measures including lean body mass should be investigated in future studies as BMI does not correlate with handgrip strength.

Conflict of interest

The authors declare that they do not have any conflict of interest to declare

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