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Dr. Sunil Kumar
2nd Year Resident Dept. of Physiology, B.J. Medical College, Ahmedabad, India.

Dr. Hardika Upadhyay
3rd Resident Dept. of Physiology, B.J. Medical College, Ahmedabad, India.

Dr. JM Jadeja
Professor & Head Dept. of Physiology, B.J. Medical College, Ahmedabad, India.

Dr. Neeta Mehta
Professor Dept. of Physiology, B.J. Medical College, Ahmedabad, India.

Correspondence
Dr. Sunil Kumar
2nd Year Resident Dept. of Physiology, B.J. Medical College, Ahmedabad, India.

Study of correlation between hand circumference and maximum grip strength (MGS)

Dr. Sunil Kumar, Dr. Hardika Upadhyay, Dr. JM Jadeja, Dr. Neeta Mehta

Abstract
Background: Normal hand grip strength is positively related to normal bone mineral density in postmenopausal women and increased mortality from cardiovascular disease and from cancer in men.
Aims & Objective: The objective of this study was to establish the correlations between anthropometric data and Body Mass Index (BMI) with maximal grip strength (MGS).
Materials and Methods: 40 males and 40 females in the age group 17-19 years were recruited for the study. MGS was measured with a computerized Hand Dynamometer (AD Instrument, Australia). BMI, forearm circumference and hand circumference were measured.
Results: There was a positive correlation between all anthropometric data and MGS in both males and females. The hand circumference had the strongest correlation with MGS in both males and females for right hand. However, the correlation was observed only in females for the left hand.
Conclusion: Hand circumference is a good indicator to predict normal MGS than BMI and forearm circumference.

Keywords: Maximal Grip Strength (MGS); Hand Circumference; Forearm Circumference

1. Introduction
Physical strength of an individual is measured by assessing the effective muscle contraction. Muscle contraction depends on cross sectional area of muscle and its intensity of recruitment. Individuals with type II fibers have greater physical endurance. The strength capability analysis is done by asking the individual to perform a particular task like pushing or lifting an object. The observations are compared with capabilities of a section of population. Muscular strength can be measured by non-motorized dynamometry (handgrip dynamometer), motorized dynamometry, with free weights, and exercise machines. Hand grip strength can be quantified by measuring the amount of static force that the hand can exert on a dynamometer. It is a reliable measurement when standardized methods and calibrated equipment are used. This eliminates the bias of different assessors or with different brands of dynamometers [1, 2]. Testing the grip strength is a useful screening tool in managing chronic wrist pain. Longitudinal studies suggest that poor grip strength is predictive of increased mortality from cardiovascular disease [3, 4]. Disparity exists in the literature over the relationship between Body Mass Index (BMI) and Maximal Grip Strength (MGS). Researchers have claimed a positive relationship in both genders, at all ages, while a few other researchers have not been able to establish any such relationship [5-8]. It has been reported that persons with longer fingers and larger hand surfaces enjoy stronger grip power. Therefore, some researchers have examined a number of factors and anthropometric variables that explain this issue. The effect of hand dimensions (Finger spans, finger lengths, and perimeters of the hand) and hand shape (the hand width to hand length ratio) on handgrip strength in male grip athletes and non-athletes has been studied. It has been demonstrated that athletes had greater handgrip strength than non-athletes and there was no significant difference between the groups in finger spans however, in finger lengths and perimeters there was a significant difference between the groups. In addition, hand length, palm width, length, forearm length, forearm circumference and wrist circumference were significantly different between the groups [9]. There are a few studies in India which have attempted to establish the relation between handgrip strength and anthropometric data, particularly the hand circumference. The objective of this study was to establish the correlations between anthropometric data like BMI, forearm circumference and hand circumference with MGS in order to establish a simple model to predict Maximal Grip Strength.

2. Materials and Methods

This was a cross sectional observational study which included 40 male and 40 female healthy medical students with age (mean ± SD) 18.73 ± 1.08 years and 18.58 ± 0.73 years respectively as subjects. The study protocol was approved by the Institute's Ethical Committee and the subjects signed an informed consent statement prior to participation. Subjects with any joint problems of hand, wrist and elbow, history of fracture, neurological disorder, and deformities of upper limb were excluded from the study. Hand grip strength was recorded with the help of Grip Force Transducer by using Power lab 8/30 series with dual bioamplifier (AD Instruments Australia, model No. ML870). Hand grip strength of both the hands was measured using a computerized hand dynamometer with participants seated with their elbow by their side, flexed at right angle with a neutral wrist position. The maximal grip strength (MGS) task consisted of a gradual increase in force from zero to maximum over 3 s. The maximal force was maintained for duration of 2–3 s. Mean of three trials of grip strength for right hand was calculated. BMI, forearm circumference and hand circumference were measured. BMI: The height was recorded during inspiration using a stadiometer to the nearest 0.1 cm, and weight was measured by digital standing scales to the nearest 0.1 kg with the subjects wearing light indoor clothes and without shoes. BMI was then calculated using the formula weight (in kg)/height(m) 2 Hand circumference: Hand circumference was measured at maximum hand width by flexible measuring tape. Forearm circumference: Forearm circumference was measured at midpoint between olecranon process of ulna and styloid process of radius bones by flexible measuring tape. Pearson's correlation coefficient test was applied to study the correlation.

3. Results

There was no significant difference in mean BMI between males and females (P>0.05). There was a statistically significant difference in forearm circumference and hand circumference in both upper limbs between males and females (P<0.05).There was a significant gender difference in hand grip strength with males having greater values than females (p<0.05) (Table 1). There was a positive correlation between all anthropometric data and MGS in both males and females. The hand circumference had the strongest correlation with MGS in both males and females for right hand. However, the correlation was observed only in females for the left hand (Table 2, 3).

Table 1: Maximal Grip Strength (MGS) & Anthropometric parameters in Males and Females

Parameters	Males (Mean ± SD)	Females (Mean ± SD)	'p' value
BMI (Kg/m2)	21.74 ± 2.86	21.30 ± 3.6	>0.05
Right Hand MGS (N)	406.25 ± 70.11	195.65 ± 54.09	<0.05
Right hand Circumference (cm)	21.79 ± 1.10	19.03 ± 0.862	<0.05
Right forearm Circumference (cm)	22.75 ± 1.41	18.86 ± 1.57	<0.05
Left Hand MGS (N)	388.10 ± 73.44	183.41 ± 49.20	<0.05
Left hand Circumference (cm)	21.33 ± 1.06	18.46 ± 0.89	<0.05
Left forearm Circumference (cm)	22.14 ± 1.49	18.275 ± 1.43	<0.05

Table 2: Correlation between Hand MGS and Anthropometric parameters in Males

Parameters	Right hand		Left hand	
	'r' value	'p' value	'r' value	'p' value
BMI	0.198	<0.05	0.212	<0.05
Hand Circumference	0.447	< 0.05	0.168	>0.05
Forearm Circumference	0.163	<0.05	0.248	<0.05

Table 3: Correlation between Hand MGS and Anthropometric parameters in Females

Parameters	Right hand		Left hand	
	'r' value	'p' value	'r' value	'p' value
BMI	0.247	<0.05	0.200	<0.05
Hand Circumference	0.349	<0.05	0.313	<0.05
Forearm Circumference	0.232	<0.05	0.240	<0.05

4. Discussion

A number of daily functions and sporting events need high levels of activity of the flexor musculature of the forearms and hands. These muscles are involved in gripping strength. Reliable and valid evaluation of hand strength can provide an objective index to strength of upper body. The synergistic action of flexor and extensor muscles, the interplay of muscle groups is an important factor in the grip strength. There are 35 muscles involved in movement of the forearm and hand, with many of these involved in gripping activities. During gripping activities, the muscles of the flexor mechanism in the hand and forearm create grip strength while the extensors of the forearm stabilize the wrist [10]. The strength of the grip is influenced by factors like muscle strength, hand dominance, fatigue, time of the day, age, gender, nutritional status, restricted motion, and pain. Nutritional status has also been correlated to handgrip strength. Guo *et al.* and Kenjile *et al.* found grip strength to be a strong predictor of an individual's nutritional status [11, 12]. These findings draw parallel to the findings of the anthropometric measurement studies. The most common method of assessment for grip strength is the use of a handheld dynamometer. This is referred as biomechanical measurement. Biomechanical measurements help to appreciate the bioenergetics and efficiency of movements. In our study males had significantly higher hand grip strength than females. This was in accordance with earlier studies [13, 14]. The reasons for this finding are attributable to increased bone mineral density and muscle mass in males when compared to females. There was a positive correlation between all anthropometric data and MGS in both males & females. Hand circumference had the strongest correlation with MGS. This finding was similar to the report from study which showed strong correlation between hand circumference and MGS [15]. Further studies on larger population are required to generate normative data for clinical use in hand and upper limb rehabilitation, and possible screening for other health issues.

5. Conclusion

Hand circumference is a good predictor of muscle grip strength (MGS) than BMI and forearm circumference.

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