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Fore Arm Circumference and Hand Length Predicts Maximal Hand Grip Strength among Malaysian Population

[1]Vikram Mohan, [1]Noor Shafiqah Bt Shamsaimon, [1]Muhammad Izzat Bin Japri, [1]Nor Effendi Bin Yasin, [2]Leonard Joseph Henry and [3]Ida Rosmini Othman

[1]Department of Physiotherapy, Faculty of Health Sciences,
Universiti Teknologi MARA, Puncak Alam, Selangor, Malaysia
[2]Physiotherapy Program, School of Rehabilitation Sciences, Faculty of Health Sciences,
Universiti Kebangsaan Malaysia, Kuala Lumpur, Malaysia
[3]Center for Statistical Studies, Faculty of Computer and Mathematical Sciences,
Universiti Teknologi MARA, Shah Alam, Selangor, Malaysia

Abstract: Maximal Hand Grip Strength (MHGS) serves as a measure of overall muscle strength and endurance. Nevertheless, variations in measuring anthropometric variables and its association with the MHGS protocols characterize dissimilar results which restrain to make use of this measure as an outcome measure. The objective of the study was to analyze association and predictors between MHGS and hand dimensions variables using a standardized protocol. MHGS was measured using Jamar hand dynamometer and anthropometric variables such as forearm circumference, wrist circumference and hand circumference, hand and palm length were measured using measuring tape for both hands. Dominant Hand (DH) variables, forearm circumference (0.396), wrist circumference (0.349) and hand circumference (0.341), hand (0.424) showed largest correlation than NDH. The anthropometric variable such as forearm circumference and hand length were systematically selected through Step wise multiple regression. These variables established a realistic results ($r^2 = 0.230$, $r^2 = 0.209$) for DH and NDH respectively. Hence, it can be accomplished that Forearm circumference and hand length can be predicted using MHGS for DH and NDH among Malaysian population.

Key words: Hand Grip · Circumferential Measurement · Strength · Dynamometer

INTRODUCTION

Maximal Hand grip strength (MHGS) is one of the commonest measurements used as a part of physical assessment among various diseases affecting musculoskeletal, neuromuscular, respiratory system, critically ill subjects, elderly and obese population [1-6]. It also renders selective information to forecast nutritional status of an individual [7]. Consequently, overall muscle strength can also be forecasted using MHGS as an indicator [8]. It has been reported impaired preoperative MHGS may be associated with morbidity and mortality following surgery [9]. Therefore, a decrease in MHGS can cause significant functional limitations which could lead to decreased activities in daily living thereby the quality of life.

Measurement of MHGS can be performed by LIDO kinetic work set and using variety of dynamometers. Common forms of dynamometers which are in use include jamar, the martin virgometer and the myogrip [10-14]. These equipments are used for establishing normal values and for predicting the involvement of anthropometric variables for MHGS. Recently, researchers have shown an increased interest in standardizing the

Corresponding Author: Vikram Mohan, Senior Lecturer, Department of Physiotherapy, Faculty of Health Sciences, Universiti Teknlogi MARA (UiTM), Puncak Alam, Selangor, Malaysia.
Tel: +603 32584367.

protocol for measuring MHGS using Jamar dynamometer. A review by Roberts HC, 2012, accounted that majority of the studies using jamar dynamometer suggests positioning strategies and second handle position for the dynamometer as advised by the American Society of Hand Therapists (ASHT) [15].

To date, the relevant literature in Malaysia shows the normative values for MHGS and its association with height and body mass index using LIDO kinetic work set and Jamar dynamometer [10, 11, 13]. The protocol followed in these studies are based on the Illinois state and the New York State University. Furthermore the information established has shown that gender, hand dominance, age, occupation, weight and height need to be considered, when establishing normal values for grip strength. However, these norms may not be representative of a whole country as the subjects are recruited from a single setup [10-11]. Recent developments in this field demonstrated that MHGS was positively associated with height and body mass index and negatively associated with age for both sexes in an adult Malaysian population [13].

Apart from these established association with height and body mass index, forearm and hand circumference have also been proposed to be a better indicator for MHGS. Anakwe RE *et al* suggested a difference in forearm circumference of more than 2 cm may cause diminished grip strength among middle aged subjects [17]. Li *et al* proposed hand circumference could be used for predicting MHGS among undergraduate students [12]. To date, there has been little agreement on which anthropometric variables need to be employed for predicting MHGS.

Moreover, predictive models for MHGS with forearm and hand circumference have not been established so far in this region. The available literatures for predictive models are applicable to Western population and other regions. Each and every predictive model is proposing different variables for predicting MHGS on different subjects with narrow age groups. Hence, there is a wide variation in the information available regarding MHGS in following the protocol and its predictors using jamar hand dynamometer in healthy adult subjects. Restraining these elements in to considerations, a study was carried out to identify relationship and predictors between MHGS and hand dimensions using a standardized protocol with jamar hand dynamometer.

MATERIALS AND METHODS

This was a cross-sectional study, conducted between September 2012 and March 2013, in central region of Peninsular Malaysia. Four residential areas in Kuala Lumpur, Malaysia were included into the study. All healthy subjects aged 20 to 69 years old were invited to participate in this study. A total 624 subjects comprised 423 males and 201 females participated in the study. Subject's information sheet and written informed consent were provided in English and Bahasa Malay language to obtain consent from all the participants prior to data collection. The study received ethical approval from Research Ethics Committee (REC) of Universiti Teknologi MARA (UiTM).

Subjects were eligible if they were aged = 20 to 69 years old. Subjects with restriction of movement in upper extremities, musculoskeletal injuries to the upper limbs and those who are diagnosed with cardiovascular and pulmonary illness were not included in this study. Age, height, weight and hand dimension anthropometric measurements were obtained from each subject by a single researcher. Height and weight was measured using SECA weight and height scale (Vogel & Halke, Hamburg, Germany).

Hand Dimension Measurements: The measurement techniques of hand dimensions were carried out by using a standard measurement tape as proposed for both hands [12, 18]. Dominant hand was defined as the one which preferred for daily activities such as writing and eating. Largest and thinnest parts of forearm were taken for forearm and wrist circumference. Perimeter of the middle part of the hand was considered for palm length. For palm length, distance from the distal wrist crease up to the base of the middle finger and lastly for the hand length, the distal wrist crease to the tip of the middle finger was considered for measurement. All the measurements were measured to the nearest centimeters with the hand extended and relaxed while elbow was supported on a table.

Hand Grip Measurements: It was measured using a standard, adjustable-handle Jamar dynamometer which has good to excellent test-retest reproducibility and excellent inter-rater reliability [15]. Initially, the testing procedures were explained and demonstrated to the test participants. Then the test was performed with the handle

in the second position with the subjects seated on a chair, their shoulders abducted, elbow flexed at 90°, forearm in neutral and wrist between 0 and 30° of dorsiflexion as recommended by American Society of Hand Therapists (ASHT). Each subject was tested for both right and left hands. Three measurements from each subject were gathered and the mean value was being used in all analyses. Handgrip strength was recorded as maximum kilograms of force during the procedure.

Data Analysis: All Statistical analyses were performed using the Statistical Package for Social Sciences version 17.0. Demographic data were analyzed using descriptive statistics. Normality assumptions were established by inspecting the q-q plot together with skewness and kurtosis for both men and women separately. Pearson correlation analysis was used to compare the influence of MHGS and hand dimension variables. A stepwise multiple linear regression analysis was employed to assess the relative contributions of factors that influence MHGS and these are presented as adjusted R^2 statistics. This reflects the percentage of overall variability in the dependent variables that were included in a multiple linear regression model. Statistical significance was accepted for *P* values of < 0.05.

RESULTS

A total of 624 subjects participated in this study, which comprised of 423 males (67.8 %) and 201 females (32.2%) with mean age of 40.28 ± 14.31 between 20 to 69 years old. Demographic characteristics of the subjects such as age, weight, height, body mass index (BMI) and hand dimensions were presented in Table 1. Hand dimensions readings are presented for both dominant hand (DH) and non-dominant hand (NDH).

All anthropometric variables being studied in this study demonstrated significantly greater readings in males than females. Males had the strongest mean HGS of 34.18kg and 30.16 kg as compared to females with 21.08 kg and 18.16 kg for dominant hand (DH) and non-dominant hand (NDH). Mean values for Forearm circumference was also significantly greater in males (DH: 27.32cm, NDH: 26.88) than in females (DH: 24.14cm, NDH: 23.76cm). Similarly, palm length also showed highest mean in males for both hands (10.73 cm) compared to females (10.15cm).

Pearson's correlation coefficients between MHGS and anthropometric data are provided in Table 2. DH's anthropometric variables showed largest correlation than NDH. Table 3 provides the successive parameters entering the regression model in the order defined by the stepwise method. Forearm circumference and hand length for both hands were selected for the regression model. Thus, two regression functions were established in Table 4. Adjusted r^2 proved that these regression functions are positively associated to predict maximal HGS when considering the forearm circumference and hand length.

Thus, these equations were predictive of maximal HGS among both genders for both DH and NDH. Hence, it can be said that HGS can be predicted by using forearm circumference and hand length for both DH and NDH.

Table 1: Demographic Characteristics and anthropometric data of the subjects

		Males (n= 423)	Females (n= 201)
		Mean ± SD	Mean ± SD
Age (years)		42.65 ± 13.7	35.31 ± 14.34
Height (m)		1.65 ± 0.08	1.55 ± 0.06
Weight (kg)		71.93 ± 11.18	57.17 ± 12.96
BMI (kg/m²)		26.62 ± 4.29	23.81 ± 5.25
Forearm circumference (cm)	DH	27.32 ± 2.06	24.14 ± 2.72
	NDH	26.88 ± 2.09	23.76 ± 2.72
Wrist circumference (cm)	DH	16.95 ± 1.65	15.3 ± 1.54
	NDH	16.78 ± 1.69	15.17 ± 1.56
Hand circumference (cm)	DH	20.87 ± 1.98	18.88 ± 1.76
	NDH	20.60 ± 2.07	18.56 ± 1.75
Palm length (cm)	DH	10.73 ± 1.21	10.15 ± 1.02
	NDH	10.73 ± 1.21	10.15 ± 1.22
Hand length (cm)	DH	18.80 ± 1.25	17.4 ± 1.25
	NDH	18.82 ± 1.26	17.33 ± 1.48
Grip strength (kg)	DH	34.18 ± 8.64	21.08 ± 5.98
	NDH	30.16 ± 9.10	18.16 ± 5.44

Table 2: Pearson's correlation coefficient between grip strength and anthropometric data

		HGS
Forearm circumference	DH	0.396**
	NDH	0.376**
Wrist circumference	DH	0.349**
	NDH	0.335**
Hand circumference	DH	0.341**
	NDH	0.310**
Palm length	DH	0.235**
	NDH	0.242**
Hand length	DH	0.424**
	NDH	0.402**

DH= dominant hand, NDH= non-dominant

** Correlation is significant at the 0.01 level (2-tailed)

Table 3: Variables selected for the stepwise multiple linear regression models.

		MLR				
	Variables	B	(95 %CI)	F-stat (df)	p-value	Adjusted r²
Dominant	Forearm circumference	0.941	(0.66, 1.22)	94.17 (2,621)	<0.001	0.23
	Hand length	2.185	(1.64, 2.73)			
ND	Forearm circumference	0.89	(0.61, 1.18)	83.18 (2, 621)	<0.001	0.21
	Hand length	1.92	(1.42, 2.43)			

Table 4: Regression prediction equation by stepwise multiple linear model.

Grip strength	Regression prediction equation	Adjusted r²
Dominant	MGS = 2.19 (Hand length) + 0.94 (Forearm circumference) - 34.87	0.230
Non dominant	MGS = 1.92 (Hand length) + 0.89 (Forearm circumference) – 32.14	0.209

DISCUSSION

The present study was designed to determine the relationship and predictors between MHGS and hand dimensions using a standardized proposed protocol with second handle position of Jamar hand dynamometer. Previous work has been carried out using this second handle position globally as well as locally in this region and it has been shown that this produces MHGS [12, 13, 17]. In the present study, mean BMI were consistent with the work by other author who has carried out a study in Malaysia. The mean BMI for men and women were 26.62 kg/m^2 and 23.81 kg/m^2 respectively. This compares with the same group of population mean BMI of 24.4 kg/m^2 for men and 23.9 kg/m^{2}for women in the Asian context [13]. The results indicated all the five variables influence upper limb circumferences and in particular DH showed largest correlation when compared to NDH with MHGS. This finding supports previous research into this core area which links MHGS and anthropometric variables [16]. However, the precise influences over DH variables when compared to NDH were obvious [16]. Correspondingly, there were no proportional data from preceding studies that described influence of these circumferential variables among this region. Conversely, partial support of our present study can be compared with the earlier studies among these population in which they have concluded that hand dominance must be considered when establishing normal values for grip strength. They also have found out that DH grip strength has influence over work status for men [10, 11, 13].

Our study selected hand as well forearm circumference systematically for a step wise regression model and yielded positive capacity to predict MHGS. Similarly, an earlier study which systematically selected hand circumference as the only anthropometric variable through a stepwise circumferential regression model produced good results (r^2 =0.624) with MHGS among one hundred undergraduate students [12]. Finally, they have accomplished that 'normal' MGS can be predicted using hand circumference alone. Another group of authors pointed out that forearm circumference greater than 2cm only may provide credibility to a measurement of diminished MHGS under some pathological situation associated with pain, instability or casting [17]. Hence, the results of these studies and our study need to be inferred carefully as the results of these

studies differed in terms of outcome even though they have showed influences among the study variables.

There are several possible basic biological reasons for these results. Firstly, the presentation of skeletal muscle histology and histo-chemical parameters among these populations would have accounted for difference in values when compared to other studies. Apart from that aged populations who are recruited in our study may have altered skeletal muscle histology and ultra structural changes even though they do not have any illness such as cardiovascular and pulmonary disease. These changes can be seen as type 2 fibers atrophy among aged populations [19].Hence, these physiological changes would have showed variation in the results to predict MHGS in our study.

Similarly, the usefulness of the study also has few limitations. Firstly, the strength value of the entire individual are presented all together. Another limitation of the study is the populations recruited in this study were not homogenous as there was wide variation in the age groups. Hence, judgment regarding exact prediction of an equation can be made when restricted age groups are selected to know the influence of these variables with MHGS in this region as a future study. The data collection for the restricted age ranges are underway and it will be explored in future studies among these populations. These findings highlight the importance of MHGS assessment among anthropometric variables. Future studies are warranted to explore the mechanism underlying the exact mechanism of interaction among these variables in this population.

CONCLUSION

Forearm circumference and hand length can be predicted using maximal hand grip strength for both dominant and non dominant hand among Malaysian population.

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