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DETERMINING THE STRENGTH OF HAND GRIP FOR HEALTHY ADULTS IN RELATION WITH HAND LENGTH, FOREARM CIRCUMFERENCE, BMI AND HAND DOMINANCE

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ABSTRACT

Background: Hand-grip strength studies with healthy adults have shown correlation between anthropometric variables and hand grip strength. There is dearth in literature in population of Saudi Arabia. The objective of this study is to describe normative data to evaluate the relationship between handgrip strength and other anthropometric variables especially hand length, forearm circumference with regard to dominant hand, among healthy males in Abha, Saudi Arabia, using a Hand held dynamometer.

Methods: A sample of 99 male adults from the population of Abha, Saudi Arabia, ages 20 to 72 years were tested using standardized positioning and instructions. A Hand–held dynamometer was used to measure grip strength in kilograms.

Results: Low to medium correlation (significant) is found between all the variables and HGS. Age is negatively correlated. A stepwise regression predicts that hand length, age, forearm girth circumference are the three significant variables of hand grip strength. An ANOVA proves that hand grip strength is less for subjects above 60 years; hand grip strength is higher for subjects with extra-large forearm girth circumference.

Conclusion: Normative values hand grip strength in population of Saudi Arabia is established through this study. The hand grip strength is influenced by hand length, hand girth circumference as well as age category of the subjects and these variables can be better predictors while clinically rehabilitating hand patients.

Keywords: Handgrip, hand length, forearm circumference, dominant hand, hand held dynamometer

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INTRODUCTION

The human hand is a complex structure and is very dutiful to the functions of manipulation. It serves the purpose of conveying sensory information about temperature, shape and texture of any object to the brain [1]. The ability to perform firm grip, together with highly elaborated nervous control and sensitivity of fingers, helps to deal with daily demands of life [2,3]. Grip strength is the strength of several muscles in the hand and its power is the forceful flexion of all finger joints, with a maximal voluntary force. The force has most commonly been measured in kilograms and pounds, some studies have also used millilitersof mercury and also newton's.[4]Anakwe et al., has observed that associations with forearm and hand circumference have also been proposed to be better indicators of grip strength [4].

Balogun et al has used prediction regression models for analyzing grip strength with independent variables like gender, age, weight and/or height either in children, inadults or in aging people [5-10]. Saaki et al has also shown that hand grip strength is positively correlated not only to height and weight butalso to BMI and anthropometric hand measurements [11-13]. Many hand-grip strength studies with healthy adults have shown that anthropometric variables such as hand length and hand width to be positively associated with grip strength [14-15]. Researchers have also proved that hand grip strength is influenced by posture and other anthropometric traits like fat percentage and hand perimeters [16]. A thorough literature survey byKoley et al., elucidates the disparity that exists in the literature over the relationship between hand grip strength and BMI, many researchers claiming a positive relationship between grip strength and BMI in both genders and all ages, while other researchers found no relationships [17-19]. To date, there has been little agreement on which anthropometric variables need to be employed for predicting maximum hand grip strength [20].

Grip strength can be measured quantitatively using a hand dynamometer. Hand grip strength measurement becomes more reliable only when standardized methods and calibrated equipment's are used even when there are different assessors or different brands of dynamometers [21]. Although numerous dynamometers have been developed, researchers have turned toward the use of models with adjustable handle settings allowing for adjustment of the instrument to the size of the human hand or for assessing strength at various spans of grip [22,23].

Various anthropometric measurements such as hand breadth, hand length, or circumferences of the wrist and forearm have been studied, but the evidences are still scarce and varied in its relation with hand grip strength (HGS). Fallahi and Jadian have reported that even though HGS has been investigated frequently, there are inadequacies in examining hand anthropometric characteristics [24]. There is a dearth of such study among Saudi population and the available literature for predictive models are descriptive of the Western population. Presently normative data regarding hand grip strength is very less in Saudi Arabia.

The research question thus posed for the study is, Is there a relation between anthropometric measures and hand grip strength? The objective of this study is to describe normative data to evaluate the relationship between handgrip strength and other anthropometric variables namely BMI, hand length, forearm circumference with regard to dominant hand, among healthy males in Abha, Saudi Arabia, using a Hand held dynamometer. The study may be unique that it tries to further characterize and describe the statistically significant anthropometric variables related to hand grip strength.

MATERIALS AND METHODS

This non experimental correlational descriptive study was conducted in Abha, Saudi Arabia after obtaining approval from KKU University Ethical Committee prior to the commencement of the study. The study included 99 asymptomatic healthy subjects. Exclusion criteria are 1) people with recent hand injury or surgery, 2) hand deformity, 3) hand swelling or edema, 4) any vascular or neurological problem, 5) hypo mobility or hyper mobility of the hand, and6) pain or inflammatory condition of the hand. Subjects are assessed for the - height (cm), weight (kg), body mass index (BMI) as recommended by World Health Organization (WHO).

Procedure:

Subjects are taught about the procedure. The BMI, forearm circumference and hand lengthare measured. To measure HGS, a Hand held dynamometeris used. Participants are seated in a chair without an arm rest with the elbow flexed to 90 degrees and wrist slightly extended and slight ulnar deviation. Then participants are asked to maximally grip the dynamometer. Participants are given specific commands to obtain maximum reading of grip strength during trials. Standard 3rd handle position is used through-out the study performing 3 trials for the dominant hand with regular interval of 2 minutes rest period between trials. Hand length is measured from the wrist crease to the tip of the middle finger using a measuring tape. Forearm girth circumference is measured from the elbow joint down from the cubital fossa 3 cm using a measuring tape.

Picture 1: Standard Hand Grip Strength Evaluation

Data Analysis:

Statistical analysis is performed using the Statistical Package of Social Sciences SPSS-22. Demographic data is analyzed using descriptive statistics. After establishing normality of the data using Shapiro-Wilks, a bivariate correlation followed by a stepwise regression analyses is used to compare the influence of anthropometric data and hand grip strength. Average of three successive trials of hand grip strength is used for the study. Pearson's correlation analysis provides a better understanding about the relation between anthropometric variables and hand grip strength. The hand grip strength values between the right and left sides according to dominance are used as the dependent variable for the step wise regression analyses. The statistically significant variables are further analyzed using ANOVA. Variables tested were height, weight, BMI, age, hand length, and forearm girth circumference, with the hand grip strengthas the dependent variable.

RESULTS

The study includes 99 subjects ranging between 20 – 72 years of age (Table 1). When compared with the hand length classification, the hand lengthfalls under the large and very large category, more than 17 cm in length. Like wise the forearm girth circumference falls under the category of large (24 cm and above) and extra-large (above 26 cm).

Table 1: Mean and Standard Deviation of Constructs in the Study (n=99)

Constructs	Mean (SD)
Age	43.19 (15.2)
Height	169.98 (7.64)
Weight	79.20 (15.67)
BMI	27.30 (5.06)
Forearm Circumference	28.07 (1.74)
Hand Length	19.01 (0.82)

Pearson's correlation analysis shown in Table 2 shows the correlation between age, height, weight, hand length, forearm girth circumference, and handgrip strength. Dominant hand grip strength has significant correlations ($p \leq 0.05$) with all the variables. Though the correlations are low to medium, all the variables are shown to be statistically significant correlations with HGS. Age has a negative correlation with HGS.

Table 2: Correlation between anthropometric variables and HGS

Variables	r (correlation coefficient)
Age	-0.391 **
Weight	0.198*
Height	0.362**
BMI	0.300**
Hand Length	0.412**
Forearm girth Circumference	0.380**
** p ≤0.01, * p≤ 0.05	

Stepwise multiple linear regression analysis is used in order to elucidate the relation between the variables and hand grip strength. This analysis is used because it is both predictive and can establish a linear trend among the independent and dependent variables. This multivariate analysis comprises both correlation coefficient (R) as well as percentage of variance (R^2). The regression functions shows that hand lengthand forearm girth circumference are positively associated, whereas age is negatively associated to predict HGS. A detailed Analysis of Variance (ANOVA) provides better understanding about the significant independent variables.

Table 3 provides the successive variables entering the regression equation in the order defined by stepwise regression. Age, height, weight, BMI, hand length, forearm circumference are the independent constructs (Table 2). The variables are not preselected, and this regression analysis provides a better model fit if the population is small.[25] Figure 1 provides a scatter plot for the three significant variables in the equation. Forearm circumference, age and hand length are the three constructs selected in the model by stepwise regression. Hand length has a correlation of 0.412 with handgrip strength. It explains 17% of variance of handgrip strength (R^2=0.17). The second variable in the equation is age. It explains 10% of variance in handgrip strength (as reported by R^2 change) and both the variables together contribute for 27% of handgrip strength. The t-value of age is negative which indicates that as age increases the hand grip strength declines. The third construct in the equation is forearm girth circumference which contributes for 7% of variance in hand grip strength and the three variables together predicts 34.7% of variance in hand grip strength. The regression equation is thus HGS (y) = -13.92 + 0.204 hand length -0.368age + 0.312 forearm girth circumference.

Table 3: Stepwise regression model

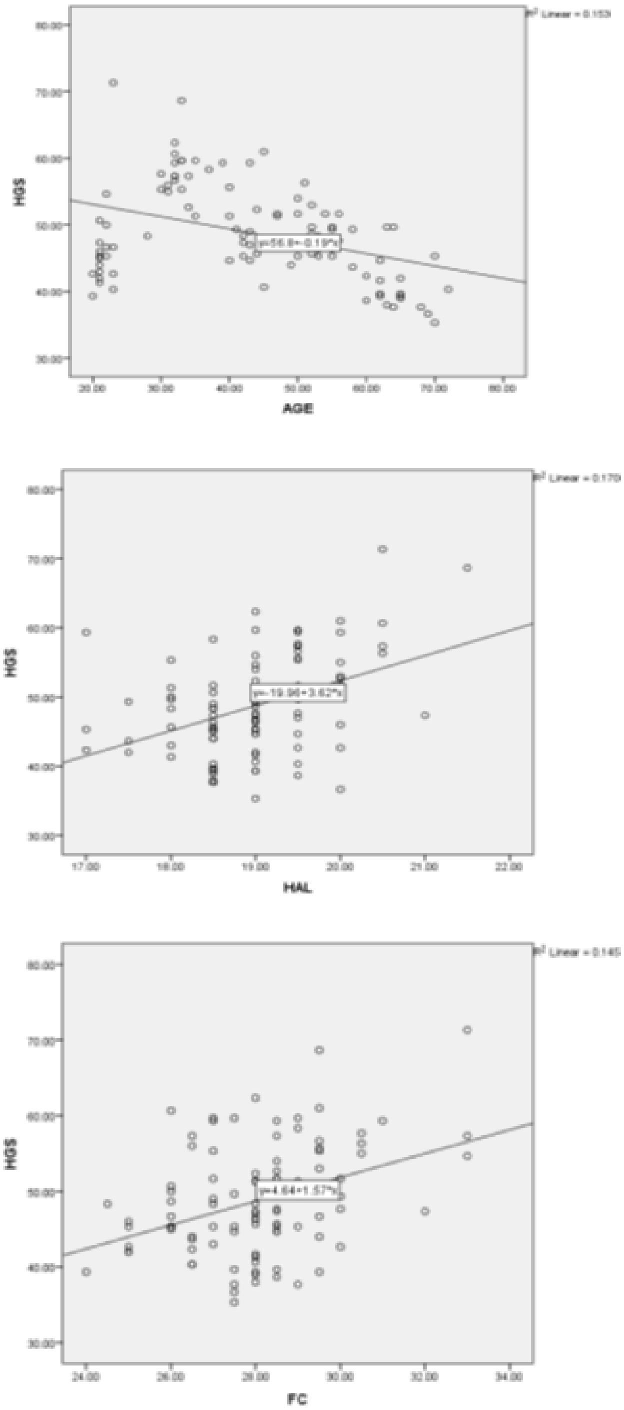
Variables in the equation	R	R^2	R^2 change	Standardized Beta Coefficients	t- value	p-value
HL	0.412	0.170	0.170	0.204	2.14	<.001
HL, Age	0.519	0.270	0.100	-0.368	-4.29	<.001
HL, Age, FC	0.589	0.347	0.77	0.312	3.348	<.001
FC: Forearm Circumference, Age, HL: Hand Length, p ≤.01						

An ANOVA is used to elucidate whether there is a significant difference between age, hand length, forearm circumference characteristics, and HGS of the dominant hand. The results of ANOVA are reported in Table 4. It is evident from Table 4, that there is no significant difference between hand length classification and hand grip strength, though it is a very significant contributor to predicting hand grip strength. Age has shown a negative relation with hand grip strength and ANOVA shows that hand grip strength is higher for respondents in 30-39 years of age. Hand grip strength is less for 60 and above age category subjects. Hand grip strength is higher for subjects with extra-large forearm girth circumference.

Table 4: ANOVA

Variables in the equation	Mean Value	F value	p-value
Hand length	47.78 (large)	2.001	.161 (N.S)
	49.98 (extra-large)		
Age	46.63 (20-29)	32.508	<.001*
	57.98 (30-39)		
	49.26 (40-49)		
	48.88 (50-59)		
	40.87 (60 above)		
Fore Arm Circumference	46.40 (large)	22.15	<.001*
	52.81 (extra-large)		
NS: Non significant, * p≤.01			

Figure 1: Scatter plot of Age, Hand length and Forearm circumference on Hand grip strength



DISCUSSION

In case of height, weight, and BMI, a positive correlation with the hand grip strength is found in this study. It could be the result of various factors such as the effect of heights on arm length. This result is in concurrence with other studies which has showed that lever arm for force generation is affected by the length of the arm resulting in an efficient amount of force. Gandhi et al., 2010 and Kauley and Kaur (2011) also showed that handgrip strength had strong correlations with various anthropometric characteristics, like height, weight and BMI [25,26].

Age shows a low negative correlation with hand grip strength in the present study. Despite numerous studies demonstrating a significant relationship between increased age and reduced hand dexterity, few studies have attempted to investigate the causes of the relationship as observed by Martin et al., 2015.[27]The negative correlation between age and HGS can be explained by the decline in musculoskeletal strength and mass associated with aging as suggested by Marmon et al., 2011 [28]. Hand length and forearm girth circumference is also positively correlated with hand grip strength (r of 0.412 and 0.380 respectively). The result goes hand in hand with Everret and Sills, 1952 (as cited in Bowers, 1961) has reported that hand length along with hand breadth and forearm girth has positive correlations with hand grip strength. However, they have concluded that none of these factors could be singled out as predictive of hand grip strength [29]. This research provides a predictive model to understand the major anthropometric variables in relation to hand grip strength.

Step wise regression analysis has excluded weight, height, and BMI from the predictive model. Past research exploring the relationship between BMI and hand grip strength has provided incongruent findings. The study results are in line with that of Westroppet al., who have found that BMI is not correlated to hand grip strength in their study [18]. Hand grip strength is negatively associated with physical frailty especially body mass index (BMI) [30]. Hutasuhut and Royoto, 2014 has also reported to find no significant associations between BMI and hand grip muscle strength [31]. Jurimae et al., 2009 has also reported that the most important predictive value for grip strength from the basic anthropometric variable like body height is not related to grip strength [32]. In a study of hand grip strength among Korean population Lee et al., 2012, has pointed out that only height and BMI to be significant contributors to hand grip strength while weight of the subject was not a significant predictor [33]. Though weight is correlated with hand grip strength it is not a significant predictor of HGS. The reason could be the age-related changes in body composition particularly increased fat, central fat deposition, and decreased lean mass [33,34].

Hand length, age, and forearm girth circumference predicts 34.7% of HGS. The result of this study is in concurrence with former studies for example, hand length and forearm circumference contributing to 23% of HGS, age contributing for nearly 19% of HGS and is a significant variable in logistic regression equation as shown by Chandrasekaran et al., 2010 [35]. Hand length is the most significant variable in predicting hand grip strength according to this study. The results of the study is in congruence with-Hager-ross and Schiebe (2000) whohaveconfirmed in their study that hand length is an important variable for handgrip strength [36]. Middle grip spans seem to favor greater forces than smaller or larger grips as observed by Blackwell et al., 1999 [37]. Hand span affects grip strength, grip force, and exertion level as reported by Ruitz et al., 2006 as well as Oh and Radwin (1993) [38,39] ANOVA results shows no significant difference in the hand length classification and hand grip strength. Earlier studies have shown that grip strength changes in accordance with the size of the hand, and researchers have shown that children's hand size is smaller, therefore a lower grip strength in teenagers. Teenagers have lesser hand span in comparison with adults and therefore lesser HGS. In this study, the respondent adults have a bigger hand span (mean of 19 cms), which fall under the category of larger and extra larger hands as reported by Romero et al., 2008 [40]. This could be a new understanding to measuring handgrip strength and might be the reason for the non-significant ANOVA.

Age is a significant predictor of HGS and shows a negative t- value. ANOVA results show that HGS declines for subjects above 60 years of age. Some researchers reported that ageis associated with diminished hand grip strength, and found association between moderate hand strength and general muscle mass reduction due to age as observed by Vianna et al., 2007 [27,41]. The result of this study is in congruence with the early findings. Forearm girth circumference is found to be a better predictor for normal hand grip strength [20] and therefore is a good indicator of measuring hand grip strength. ANOVA results indicate that the larger the circumference is larger the hand grip strength. Hand circumference is studied to be a very good indicator of body stature, hence a good estimate of physical capacities as held by Hogrel, 2015 [42]. Therefore, it can be concluded that the higher the circumference the higher the HGS would be.

Limitations of the study included the following the small sample size makes it difficult for generalizations, the study population is limited to males therefore a variance in gender could not be explored, therefore, it would be much comprehensive if a future research can be conducted among women.

CONCLUSION

It can be concluded that hand grip strength of normative population is influenced by the hand length of the subjects, age, and forearm circumference. Hand length, age, and forearm circumference should be important predictor variables during the rehabilitation of patients with hand injuries. The detailed analysis on classifications of age and forearm circumference may make it unique and may provide in-depth understanding for physical therapists about hand grip strength.

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