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Influence of Basic Anthropometric Variables on Pinch Strength of Dominant Hand in Healthy Individuals

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SUMMARY

Background. Pinch strength is a simple, affordable, and effective way to measure upper-limb function. The study aims to determine how anthropometric variables affect maximal pinch strength in normal individuals.

Methods. One hundred and eighteen participants were included in the study using non-probability, non-random convenience sampling technique. The pinch strength was measured three times in each participant with a gap of 5 s in each reading. The measurement was taken with elbow in 90-degree flexion and forearm in mid pronation position. The data was then encoded in SPSS v25 for statistical analysis. Pearson's correlation and Multiple linear regression analysis was performed on the data.

Results. A total sample 118 participants included 54 males (45.7%) and 65 female (55.1%) participants, with mean age of 23.19 (SD = 2.02) and mean weight of 64.24 kg (SD = 12.4). The mean pinch strength was 9.23 kg (SD = 3.9). The r-value of Pearson's correlation between the max pinch strength and age, weight, height and BMI were negative 0.052 ($p = 0.707$), 0.576, 0.564, 0.384 ($p < 0.01$), respectively. The R-squared and adjusted R-squared value for the multiple linear regression model were 0.328 and 0.327 respectively.

Conclusions. The maximal pinch strength is influenced by the basic anthropometric factors including weight, height, and BMI. The strongest indicator of pinch strength in normal persons is body weight.

KEY WORDS

Anthropometry; Body Mass Index; hand strength; pinch strength; upper extremity.

INTRODUCTION

Normal physiological biomechanics rely heavily on the hands and arms. Daily activities involving the upper body include clothing, eating, drinking, driving, and doing office duties, among others. Thirty bones comprise the arm's fundamental structure and serve as attachment sites for muscles, ligaments, and tendons (1). When these bones move together, they help us conduct all our daily actions (2).

Hand grip strength (HGS) is one of the most common measurements used to evaluate upper limb functions. This measure can be used to evaluate the total muscular strength and physical fitness of individuals (3). HGS is crucial in determining the efficacy of interventions that can improve hand functioning after injury or illness. This outcome metric can predict postoperative morbidity and death (4). Better hand strength is directly related to greater mobility, fewer limitations, and the capacity to do daily activities with ease (5).

There are multiple factors that influence the maximum grip strength. These can be divided into two different categories. They can be measurement-based factors such as the angle and position of the shoulder, elbow and wrist joint while measuring the grip strength (6), or as physiological factors, including muscle strength and anatomical structures of the hand and forearm (7, 8).

Greater hand grip strength has been associated with larger bone size and greater bone strength in addition to higher bone mineral density (9). Anthropological studies relating to hand grip strength have shown that the maximum hand grip strength is associated with body weight, height, BMI, gender and age group (10).

Numerous studies have demonstrated a correlation between hand grip strength and key anthropometric factors. Mohd Mukhtar Alam *et al*. have investigated the association between hand strength and fundamental anthropometric characteristics in a variety of research (11, 12). When evaluating hand strength, it is essential to mention pinch strength as well. Numerous studies have proven the link between HGS and PS under various settings (13). However, comparatively a few research has examined the link between the basic anthropometric factors and pinch strength individually (14).

Similar to hand grip strength, pinch strength is a useful predictor of total upper limb functioning (15). In addition to shoulder, elbow, and wrist posture, the pinch strength also relies on the type of pinch performed. The principal techniques consist of tip pinch, lateral pinch, and three jaw pinches. Kelsey Walukonis *et al*. demonstrated in their paper that the maximum pinch strength readings for each style varied according to different reading style (16).

Although much effort has been made to determining the optimal position of upper limb joints to achieve optimum pinch strength (17), relatively little is known about the influence of body anthropometric factors on maximal pinch strength. Therefore, the purpose of this study was to examine the effect of basic anthropometric parameters, including height, weight, and BMI, as well as age, on the maximal pinch strength of normal subjects.

MATERIALS AND METHODS

A total of 118 participants were selected for this cross-sectional study using non-probability, non-random convenience sampling technique. The parameters used for calculation of sample size were level of significance 5%, power of test 95%, and population standard deviation at 3.4. Following formula was used to calculate the sample size $n = \sigma^2 (z1 - \alpha/2 + z1 - \beta)^2 / (\mu_0 - \mu_\sigma)^2$. The study was completed between April 2022 and June 2022. All the ethical considerations in accordance with the declaration of Helsinki were taken under consideration before the start of the study. In accordance with the inclusion criteria, only participants between the ages of 18 and 55 who can perform daily activities with their upper limb without the use of an assistive device and who have no known disorder or disease that could influence the results of the study were included in the data collection process. All the participants who did not fall in the above-mentioned inclusion criteria were excluded from the study. The exclusion criteria eliminated those with known musculoskeletal or neurological diseases, a history of trauma and a hand fracture within the last six months, as well as those over the age limit.

The data collection was initiated after the ethical review (Institutional Review Board, Faculty of Allied Health Sciences, The University of Lahore) approved the ethical proposal of the study (IRB-UOL-FAHS/347/2022 – Date of approval: January 29, 2022). Data was collected using “Jammar Plus Pinch strength dynamometer”. The participants were informed about the study with its benefits and the role of their participation in it after which informed consent were signed by the participants for their voluntary participation in the study. For data collection purposes, the participants were asked about their demographic data including their names, age, profession, weight and height. The maximum pinch strength was measured in 90-degree elbow flexion and wrist in mid-pronation position. Three different measurements were taken with a gap of 5 seconds between each measurement (18). The measurements were recorded in terms of SI units (kg).

The collected was then encoded into SPSS v25 and statistical test namely descriptive analysis including mean and standard deviation of all variables, multivariate linear regression along with Pearson’s correlation was applied. Normality of the sample was determined by the Shapiro-Wilk Normality Test. The multivariate linear regression included the model summary with R square values and the ANOVA table to determine the significance of the model summary of regression analysis. The level of confidence was set at 95%. The coefficients were also analyzed in the regression analysis to determine the affect of one individual predictor on the outcome. In order to test the correlation between the predictors Pearson’s correlation was applied.

RESULTS

A total sample of 118 participants included 54 males (45.7%) and 65 female (55.1%) participants. The mean age of the participants included in the study was 23.19 (SD = 2.02), while the mean weight was 64.24 kg (SD = 12.4). The height was measured in SI units. The mean height of the sample was 1.69 m (SD = 0.12). The mean of Body mass index (BMI) was 22.11 (SD = 3.75). Shapiro-Wilk Normality Test was insignificant at p = 0.66 at 95% confidence interval thus rejecting the null hypothesis for the normality of the sample size.

Pinch grip strength was measured in elbow flexion at 90-degree flexion and forearm/wrist in mid-pronation position. The average pinch strength of the three measurements of each participant was used for statistical analysis. The mean pinch strength was 9.23 kg (SD = 3.9).

To find outliers in the data set used in the multiple linear regression the residual statistics was between the acceptable range -1.388 and +1.885. which showed that there were no outlier values present in the data set. The independence of variance was calculated by the Durbin-Watson test, the value calculated is 1.640 showing an acceptable independence of variance of variables. Multivariate linear regression model summary in **table I** shows that when predictors including age, weight, BMI and gender are taken in terms of a single set, the R squared value for such model is 0.378. In other words, a set of factors including age, weight, BMI, and gender accounts 37.8% of the variation in the result of maximal pinch strength. ANOVA Test in **table II** shows that the R squared value is statistically significant ($p < 0.05$) and that the predictor set for this model has a statically significant variance for the dependent variable. Therefore, proving that the Regression model is statistically significant. The overall regression model can be defined in the following equation; $F_{(4,49)} = 7.435$, $p < 0.001$, $R^2 = 0.378$.

Table III shows an interesting result. Although the predictors in the model set had statistically significant variance, when analyzed individually, none of the predictor was statically insignificant ($p > 0.05$). The standardized beta coefficient for the age, weight, height and BMI were 0.006, 1.37, -0.24 and -0.72, respectively.

Pearson's correlation coefficient for all the variables was calculated to observe the correlation of pinch strength (PS) with age, weight, height, and BMI. The greatest predictor of pinch strength was the body's weight r = 0.576 (p = 0.01). However, it was also found that the age was negatively correlated with the pinch strength (r = -0.052), but this correlation was statistically insignificant. The Pearson's correlation between PS and age was r = -0.52 ($p > 0.05$), PS and weight was r = 0.576 ($p < 0.01$), PS and height was r = 0.564 ($p < 0.01$), PS and BMI was r = 0.384 ($p < 0.01$).

Figure 1 shows a normally distributed histogram between dependent variable *i.e.*, the pinch strength and the regression standardized values showing the normality of the data. **Figure 2** shows a normally distributed scatter plot between the standardized residual and the standardized predicted values. The P-value of Shapiro-Wilk test for standardized residual and standardized predicted value both was 0.389 which shows a normal distribution as $p > 0.05$.

Table I. Model Summary for multivariate linear regression.

Model Summary										
					Change Statistics					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change	Durbin-Watson
1	0.615[a]	0.378	0.327	3.26930	0.378	7.435	4	49	0.000	1.640

[a]Predictors: (Constant), Body Mass Index Score, Age, Height, Weight in Kg.

Table II. ANOVA table for regression model.

ANOVA						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	317.850	4	79.462	7.435	0.000[b]
	Residual	523.727	49	10.688		
	Total	841.576	53			

[b]Predictors: (Constant), Body Mass Index Score, Age, Height, Weight in Kg.

Table III. Coefficients table for the regression model.

Coefficients[a]						
	Model	**Unstandardized Coefficients B**	**Unstandardized Coefficients Std. Error**	**Standardized Coefficients Beta**	**t**	**Sig.**
1	Constant	18.454	46.249		0.399	0.692
	Age	0.011	0.233	0.006	0.047	0.962
	Weight in Kg	0.333	0.347	1.375	0.958	0.343
	Height	-2.523	8.045	-0.245	-0.314	0.755
	Body Mass Index Score	-0.762	1.056	-0.717	-0.722	0.474

[a]Dependent Variable: Right Hand PS in elbow flexion with forearm in mid-pronation.

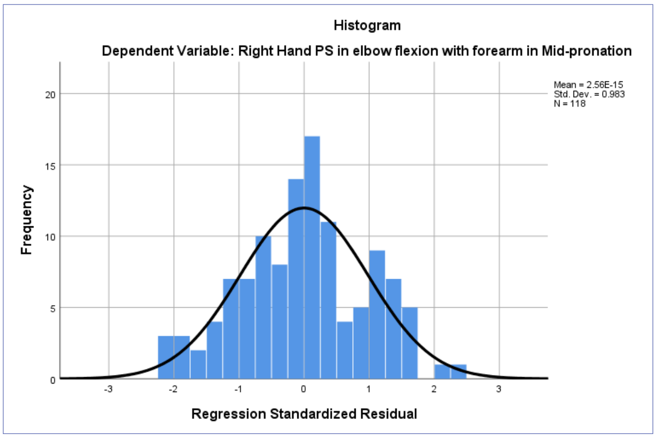

Figure 1. Histogram for regression analysis of the sample.

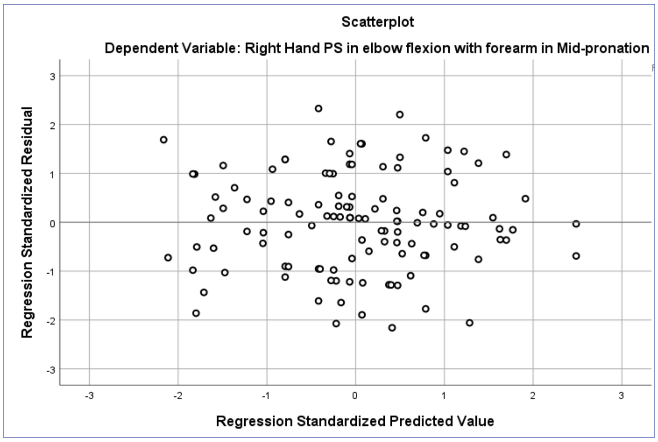

Figure 2. Scatter Plot for regression analysis standardized residual and predicted values.
y = 2.56E - 15 + 8.59E - 16 × x.

DISCUSSION

The study aimed to investigate the influence of major anthropometric variables namely height, weight and BMI on the maximum pinch strength of normal individuals. For this purpose, the pinch strength was measured with an elbow in a 90-degree flexed position and a forearm in a mid-pronation position. This position has been used in different previous studies showing that the elbow position significantly affects the pinch strength. Mathiowetz *et al.* conducted their study and concluded that the maximum strength was observed with an elbow in flexion as compared to PS with elbow extension (19). El-gohary *et al.* also studied hand grip strength and pinch strength and used the same elbow and forearm position while recording the measurements (17). However, there is a lot of literature on what joint position is best for maximum pinch strength, but much of it is 12-15 years old, making the conclusions drawn from these studies doubtful.

The results of the Pearson's correlation showed that the PS had a statistically significant and positive correlation with the weight ($p < 0.01$), height ($p < 0.01$) and BMI ($p = 0.004$). This proved that with the increase in the sample's weight, height, and BMI, the pinch strength also increased. These results are in accordance with the previous literature (20). Study by Ming-Hsun Lin *et al.* found positive correlation between the body weight and grip strength ($p < 0.01$) which is in accordance with the results of our study. Ming *et al.* also concluded in their study that people with higher grip strength had higher body weight but low waist circumference as compared to those with higher body weight and higher waist circumference. This provides another insight on how multiple anthropometric variables when discussed as a set might have impact on the outcome grip strength (21). However, Pearson's correlation for age showed that there was a negative correlation between age and the pinch strength. This measurement was statistically insignificant, which could be attributed to the fact that recent research has demonstrated that the effects of ageing on the musculoskeletal system begin in middle age (22). As our sample size included a young population with a mean age of 23.19 years, the age-related influence on the pinch strength is statistically insignificant. This can be justified by analyzing the study done by Heidi C. Crow *et al.* and Petrofsky, J.S. *et al.*, who in their studies found statistically significant difference in grip strength as a result of aging (23). However, Shaheen *et al.* in their study found a positive correlation between pinch strength and age ($p < 0.05$) and concluded that age was a significant predictor of the pinch strength across different age groups (24). Ameline Bardo *et al*. have studies that effect of anthropometric variables on pinch strength as well as on the dextrality of the hand. Our assumption from the results derived from our study was that the age was negatively associated with the maximal pinch strength, however Ameline Bardo *et al*. found that there was no significant ($p > 0.05$) difference of maximal pinch strength among the age groups of their study sample. They also found that across all the ages the maximal pinch strength was in males as compared to females providing gender as another strong variable effecting the maximal pinch strength in healthy individuals (14).

The quality of multiple linear regression model was checked by different assumptions. The outliers were determined by the standardized residual value which was, between -1.38 and +1.38, well under the threshold levels of -3.29 to +3.29. The linearity and the homoscedasticity assumptions were also fulfilled with a linear scatter plot as there was no relationship between the residuals and the dependent value's predicted value (**figure 2**). The Durbin Watson test was applied to fulfil the assumption of independence of observation. The value for this test was 1.640. The value for the Durbin Watson test need to be greater than 1.5 and less than 2.5 to fulfill this assumption (25). The results of the multiple linear regression showed that the R square value was 0.378 while that of the R square adjusted was 0.327. As our model included multiple variables therefore R squared adjusted was considered in results. The general rule of thumb suggests that value R squared adjusted above 0.25 is considered as moderately acceptable correlation. This means that weight, height and BMI from our model were correlated with the pinch strength (26). The obtained value of determination of coefficient that the independent variables included in our model (weight, height and BMI) could justify about 37% of the change in the pinch strength of the healthy young individuals. The recent studies done on grip strength are in accordance with the results of our study (12).

The study, like many others, has its limitations which may pave the way for future studies. Our study is the first of its kind to discuss the effect of basic anthropometric variables on the pinch strength. Future studies can be done to observe the influence of specialized anthropometric variables on pinch strength. The sample size was limited and was targeted only toward young individuals therefore, the aging factor was not discussed. Clinically the results of our study can provide a better understanding of the anthropometric variables such as height, weight and BMI and their influence on body functioning which can have positive impact on patient.

CONCLUSIONS

The fundamental anthropometric factors, including weight, height, and BMI, have an effect on maximal pinch strength, with body weight being the best predictor of pinch strength in healthy persons.

FUNDINGS

None.

DATA AVAILABILITY

Data are available under reasonable request to the corresponding author.

CONTRIBUTIONS

MAS: conceptualization, data collection, article composition. FA: data collection, data analysis, data interpretation. SAA: article composition, critical review, statistical interpretation. AA: manuscript formatting, data collection, final approval of submission. SAG: manuscript revision, statistical input, data collection, methodology formation.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

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