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Relationship between anthropometric variables and elbow flexor muscle strength at varying hip joint angle in apparently healthy young adults

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Abstract. Elbow flexor muscle strength testing and evaluation is an integral component of treatment programmes for musculoskeletal problems involving the elbow joint in Orthopaedic and Physiotherapy practice. The primary aim of this study was to investigate the relationship between anthropometric variables and the elbow flexor muscle strength at different testing positions. Material and *Method.* A total of 210 participants (males=105, females=105) voluntarily participated in the study. The anthropometric indices were measured using standardized procedures. The elbow flexor muscle strength was assessed using an adapted cable tensiometre. *Results.* The result showed that significant correlation was found between elbow flexor strength (assessed at four different positions), body weight and arm girth among male and female participants as well as height and forearm length among the females. There was significant gender difference in elbow flexor strength at all hip angles. *Conclusion.* Height, body weight, arm- forearm length and arm girth are directly related with elbow flexor muscle strength of apparently healthy young adults. During muscle strength testing or strengthening programme, significant consideration should be given to anthropometric variables of subject or patient.
Key words*: muscle strength, elbow flexor, anthropometric variables, muscle testing, rehabilitation.*

Introduction

Benders and Kaplan (1) defined muscular strength as the force exerted by a muscle or a muscle group at a point which may be at the extreme of any position within the range of motion. Strength is a muscle‘s capacity to exert maximal effort or resist maximal opposing force (2). It is also the capacity of a muscle or muscle group to produce tension necessary for maintaining posture, initiating movement, or controlling movement during condition of loading on the musculo-skeletal system (3). Traumatic injuries and degenerative changes problems of the elbow and knee joints requiring physiotherapy is common (4), and muscle strength testing and evaluation are required for successful management of these musculoskeletal conditions. Many factors have been reported to contribute to the determination of muscular strength. Brunnstrom (5), Walmsley and Swann (6) reported that the initial length of a muscle is a dominant factor in determining the force available for contraction and tension developed. Test position of the body during exertion of muscular strength contributes to variation in muscular strength (3,7). Body position during assessment of muscle strength is one of the variables that must be controlled to ensure the validity and reliability of isokinetic dynamometer (8-10). Body weight has been found to be good predictor of muscular strength (4,11,12). Also, muscle strength was reported to be significantly related to sex and age (13-16). Lamphier and Montoye (17) found a negative correlation between body fat and muscle strength. Garry and Mark (18), Scruddler (19), found that as the velocity of shortening increased, the muscular tension reduces.

Most of the previous research works on muscle strength were done to establish how the various arthro-kinetic positions affect the muscle length, and thus influence the tension generated. Majority of such studies were observed to have focused on the lower limbs muscle / muscle groups A recent study reported a significant difference between mean values of elbow flexor muscle’s strength measured at four different trunk positions (varying hip joint angles) (20).

Some of the researchers also evaluated muscle strength using a single test (body) position. This study was hence designed to investigate the influence of anthropometric variables on elbow flexor muscle strength of apparently healthy male and female young adult male at different trunk positions.

Material and Method

A total of 210 subjects (males=105, females=105) voluntarily participated in the study. They were male and female consenting undergraduates of the Obafemi Awolowo University, Ile-Ife, Nigeria. There ages range from 16-30 years. They signed informed consent forms after being provided with a brief description of the study. The present study was approved by the university's Research Ethics Committee and was performed in accordance with the Helsinki Declaration. The exclusion criteria for this study included history of any previous upper extremity abnormalities, inflammatory joint diseases, neurological disorder or injury to upper limb and other health conditions. The study was carried out at the gymnasium of the department of Medical Rehabilitation, Obafemi Awolowo University, OAU, Ile-Ife, Osun State, Nigeria.
This research was a cross-sectional study. The following instruments were used for the study: Body weighing balance, standiometre, inelastic tape measure, fore-arm cuff, universal goniometre, adapted cable tensiometre, and a trunk adjustable couch.
The aim and objectives were briefly explained; the procedure was explained and demonstrated to the subject prior to data collection. All the subjects reported themselves to be in good health. Participants' names, gender, and ages were sought and documented. Measurement of these indices: body weight and height, arm girth, arm length, arm-forearm length, were taking in erect standing using standardized procedures. Prior to the commencement of data collection, a practice trial was given to familiarize the subjects with the tensiometre. Before testing, the examiner demonstrated how to hold the handle of the tensiometre. The same instructions were given for each trial. For muscle strength testing, the participants sat on a plinth and placed their back on the adjustable part of the plinth with the back rest positioned at 90^o. The arm was positioned in alignment with themed-lateral side of the body (trunk), with a padded material placed under the arm. The elbow was kept at 55^o flexion position for all the subjects based on the recommendation from previous studies that maximum muscular strength is obtained when contraction (exertion) takes place in about 20% increased muscle length, from its resting position. (21,22).
The tensiometre which has been fixed to a stationary wall bar on the other end was attached to the participant's dominant arm just below the wrist; he/she was then instructed to "pull as hard as possible … harder … harder. Relax". The highest tensiometre reading was noted.
The subjects were asked to relax and rest for 2 minutes before next pull to control for the effects of fatigue. With the dominant hand used, three trials were performed in each position. Mean of 3 trials was taken and recorded as isometric elbow flexor muscle strength. The same procedure was repeated for measurements at trunk-hip angles of 120^o, 145^o and 180^o. The starting angle was randomized by balloting to distribute the possible effect of resultant fatigue (from successive contraction), in addition to the resting time.
Data Analysis. Descriptive statistics of mean and standard deviation were used to summarize the data obtained. Correlation matrix was computed to evaluate the relationship among variables. (c) Independent t-test was used to compare mean values of male and female elbow flexor muscle strength. Level of significance was set at 0.05.Data analysis was done using Statistical Package for Social Sciences (SPSS) (Illinois, USA, version 16).

Results

The mean age, height and weight of the participants was 21.65 ±2.51 years, 1.6 ± 0.07m and 60.52± 7.89 kg respectively.

Relationship between age, anthropometric variables, and the muscular strength obtained at the four (4) different test positions in male and female participants.
Presented in tables I and II, are the results of correlation matrix showing the relationship among the variables of male participants. Significant correlation was observed between body weight and elbow flexor muscle strength. Significant relationship were also noted between some anthropometric variables ($p<0.05$).

Correlation matrix testing the strength of relationship among female participants' variables is presented in tables III and IV.
Significant correlation was found between age, body weight, height, and elbow flexor muscle strength. Significant correlation was also observed between some anthropometric variables (p<0.05).

Comparison of the male and female subjects' anthropometric variables and muscular strength obtained from the four (4) different test positions.
Table V shows the result of independent t-test computed to compare demographic, anthropometric variables as well as muscle strength of male and female participants. Significant difference was obtained between the muscle strength of male and female participants.

Table I. Correlation matrix showing relationship between anthropometric measures and muscle strength of male subjects at different body positions

Variables	Age	Height	Weight	Arm length	Arm FA lenght	Arm girth
Muscle Strength 1	0.13	-0.03	0.21**	-0.04	-0.45	0.16*
Muscle Strength 2	0.12	-0.05	0.21**	-0.05	-0.08	0.19**
Muscle Strength 3	0.09	0.01	0.24**	-0.08	-0.04	0.17*
Muscle Strength 4	0.09	0.05	0.21**	0.08	0.05	0.15*

**Correlation is significant at 0.05, **Correlation is significant at 0.01; FA=Forearm*

Table II. Correlation matrix showing relationship between anthropometric measures in male subjects

Variables	Age	Height	Weight	Arm length	Arm FA length	Arm girth
Age	1.00					
Height	0.12	1.00				
Weight	0.05	0.53**	1.00			
Arm length	0.12	0.59**	0.37**	1.00		
Arm FA length	-0.17*	0.81**	0.47**	0.78**	1.00	
Arm girth	0.02	0.16*	0.41**	0.18*	0.23**	1.00

**Correlation is significant at 0.05, **Correlation is significant at 0.01; FA = Forearm*

Table III. Correlation matrix showing relationship between anthropometric measures and muscle strength of female subjects at different body positions

Variables	Age	Height	Weight	Arm length	Arm FA length	Arm girth
Muscle Strength P1	0.46**	0.35**	0.31**	0.17	0.28**	0.23*
Muscle Strength P2	0.44**	0.36*	0.32**	0.16	0.23**	0.28*
Muscle Strength P3	0.43**	0.37**	0.37**	0.18	0.23*	0.31**
Muscle Strength P4	0.40**	0.35**	0.40**	0.16	0.23*	0.36**

**Correlation is significant at 0.05, **Correlation is significant at 0.01; FA = Forearm*

Table IV. Correlation matrix showing relationship between anthropometric measures in female subjects

Variables	Age	Height	Weight	Arm length	Arm FA length	Arm girth
Age	1.00					
Height	0.22*	1.00				
Weight	0.13	0.55**	1.00			
Arm length	0.09	0.75**	0.42**	1.00		
Arm FA length	0.17	0.74**	0.49**	0.85**	1.00	
Arm girth	0.11	0.34**	0.78**	0.21*	0.30**	1.00

**Correlation is significant at 0.05, **Correlation is significant at 0.01; FA = Forearm*

Table V. Comparison of anthropometric variables, age, and elbow flexor muscle strength of male and female subjects

Variables	Subjects		t-value	p- value
	Male (n=105)	Female (n=105)		
Age (Years)	21.55±2.22	20.85±2.41	2.32	0.22
Height (m)	1.73±10E-02	1.65±6.89E-02	9.18	0.0001
Body Weight (Kg)	62.19±7.25	58.33±8.38	3.42	0.001
Arm Length (cm)	34.37±2.39	32.87±2.11	4.66	0.0001
Arm-forearm Length (cm)	63.39±3.30	60.62±3.90	5.96	0.0001
Arm Girth (cm)	26.46±2.23	25.79±2.58	1.98	0.05
Muscle S 1 (KgF)	37.80±8.57	29.30±7.60	7.70	0.0001
Muscle S 2 (KgF)	37.55±7.81	29.64±7.06	8.00	0.0001
Muscle S 3 (KgF)	26.35±5.90	20.83±5.28	7.72	0.0001
Muscle S 4 (KgF)	27.11±6.96	20.18±6.37	8.33	0.0001

Muscle S= Muscle strength at position 1-4; level of significance = 0.05

Discussion

The primary objective of this study was to investigate the likely anthropometric determinants of elbow flexor muscle strength.

Measurement of elbow flexor muscle strength is an important component of upper limb essential in muscle training, treatment and rehabilitation and it is important to understand fully factors that may influence it.

The results of the study showed that significant relationship existed between anthropometric variables: height, body weight, and muscle strength. This is consistent with the findings of previous studies (4,11).

This study also showed significant relationship existed between sex, age and muscle strength obtained at each testing position. It supported Round et al (13), Morehouse and Miller (14), Astrand (15), Jensen and Schultz (16) conclusion that muscular strength is related to person’s sex and age.

Irrespective of the test (trunk) position, significant relationship existed between sex, age, arm length, height, weight, and elbow flexor muscle strength. Miyatake et al (23) found significant correlation between height and muscle strength. This study finding also showed significant correlation between arm girth and muscles strength. According to Smirithi et al (24), muscle strength is determined by muscle girth. This study supported the finding of Ravinsakar et al (25), Leyk et al (26) which found signification correlation between muscle girth and muscle strength in both male and female participants. The implication of this finding is that during muscle testing, subjects with higher weight, height, arm girth and arm-forearm values are expected to have higher values of elbow flexor muscle strength.

Also, comparing male and female subject data, significant difference existed in the analysis of muscle strength, in all the test positions. No significant difference was found between the ages. The gender difference in muscle strength at all four trunk positions and some anthropometric variables is in agreement with the findings of Balogun et al (27) who attributed the differences in grip strength between their male and female participants to their physical characteristics rather than to the biological differences. Smirithi et al (24) also found significant difference in muscle strength with male having higher mean muscle strength.

Our study was limited to asymptomatic subjects. In our study majority of subjects were right-handed. These finding should be interpreted with caution for left handed persons. Also it was a cross-sectional study.

The results of this study indicated that relationship existed between anthropometric variables and elbow flexor muscle strength even at different trunk positions. Weight, height, arm girth and arm-forearm are likely predictors of elbow flexor muscle strength.

The implication of this is that during muscle testing and rehabilitation, individuals with higher weight, height, arm girth and arm-forearm values are expected to have higher values of elbow flexor muscle strength. Male within same age range as female, would have higher elbow muscle strength due to the likely variation in their anthropometric measures. Our study provides a glimpse of the gender difference and influence of the various anthropometric variables on elbow flexor muscle strength in young males and females.

Conclusion

It was concluded that direct significant relationship existed between anthropometric variables and elbow flexor muscle strength even at different trunk positions. It is recommended that during muscle strength testing or strengthening programme, significant consideration should be given to anthropometric variables of subject or patient. Further studies are needed to find out which factor was responsible for varying elbow flexor muscle strength obtained at different trunk position, how individual variables such as ambidexterity, work characteristics of subjects can influence elbow flexor muscle strength. Also, further study is recommended using other muscle groups.

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