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Effect of sex and neck positions on hand grip strength in healthy normal adults: a cross-sectional, observational study

Doaa I. Amin^a, Moath Z. Hawari^b, Hamada E.S. Hassan^c, Haytham M. Elhafez^a

^aDepartment of Physical Therapy Basic Science, Faculty of Physical Therapy, Cairo University, Cairo, Egypt, ^bDepartment of Physical Therapy, University of Jordan, Jordan, ^cCairo University Hospitals, Cairo, Egypt

Correspondence to Doaa I. Amin, PhD, PT, Lecturer, Department of Physical Therapy Basic Science, Faculty of Physical Therapy, Cairo University, 7 Ahmed Elzayat St., Dokki, Giza 12613, Egypt
e-mail: doaaamin38@yahoo.com

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Purpose

The purpose of this study was to assess the effect of sex and neck positions on hand grip strength in healthy normal adults.

Materials and methods

One hundred healthy adults of both sexes participated in this study. They were recruited from the students of the faculty of physical Therapy. Their ages ranged between 17 and 25 years. They were assigned to two equal groups according to their sex. Hand grip strength was measured in several neck positions. Grip strength was measured by using the Jamar handheld dynamometer, and the neck range of motion was measured by using the cervical range of motion.

Results

Among females, there was a significant difference between the hand grip strength in neutral position and in other neck positions ($P=0.036$). Among males, there was a significant difference between the hand grip strength in the neutral position and in other neck positions. Within neck positions, there was a significant difference ($P<0.001$). In addition, there was a significant difference in the hand grip strength in various neck positions between the female and male groups ($P<0.001$).

Conclusion

Hand grip strength was affected by changing the neck positions in both sexes and the maximum grip strength measurement was in the neutral position of the neck.

Keywords:

hand strength, head movement, muscle strength dynamometer

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Introduction

The human hand is exceptional at being free of periodic locomotor obligation and is committed completely to manipulative activities. Its adequacy in these functions is because of specific orientation of bones and muscles, which allows restriction of the mesh surface of the thumb to the relating surface of the other four fingertips in a firm handle, together with exceedingly apprehensive control and affectability of the fingers [1].

The hand is the most refined and differentiated musculoskeletal system in human beings, containing the biggest nervous framework in connection to its size. Full capacity and satisfactory quality of hand are essential for managing activities of daily living [2].

Hand grip strength reflects the maximum strength derived from the combined contraction of extrinsic and intrinsic hand muscles, which lead to flexion of hand joints [3]. It was originally developed for hand surgery to determine the capacity after trauma or surgery. Hand grip strength has quickly become the focus of interest in numerous studies due to its feasibility and prognostic relevance [4].

Hand grip strength is a validated and highly feasible bedside method. It is the most frequently used tool for clinical purposes. Among all muscle function tests, measurement of hand grip strength has gained attention as a simple, noninvasive marker of muscle strength of upper extremities [5].

Grip strength measurements provide a well-established and objective score reflective of the hand function. It can be easily and quickly obtained by a range of different health professionals [6]. Grip strength is widely accepted as an indicator of nutritional status, bone mineral content, muscular strength, and functional integrity of upper extremity [7]. In addition, it is considered to be an objective outcome parameter and is used to quantify outcome after orthopedic interventions of the hand [8].

Hand strength has been identified as an important factor predicting disability in musculoskeletal disease

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[9], bone mineral density [10], and the likelihood of falls and fractures in osteoporosis [11]. It even predicts complications and general morbidity after surgical intervention, general disability, and future outcome in older age [12].

Hand strength has been related with various elements – for example, demographics (age, sexual orientation), anthropometric measurements, financial variables (occupation, economic well-being, and way of life), physical, and mental variables [13], body physique characters during subject's participation [14].

Hand function estimation is helpful in the appraisal of people who experience impairment in the activities of daily living, and in the estimation of respectability of furthest point capacity and effectiveness of hand rehabilitation procedures [15].

Several studies have been conducted on the effect of neck positions on the hand grip strength, mainly concerning the neutral and rotation positions; other studies have assessed the effect of neck positions on elbow and hand strength [16,17]. Therefore, the purpose of the current study was to assess the effect of sex and neck positions (neutral, flexion, extension, side bending right, side bending left, rotation right, and rotation left) on hand grip strength in healthy normal adults.

Materials and methods

This study was conducted at the Faculty of Physical Therapy, Cairo University, in the period from July 2014 to March 2015 to assess the effect of sex and neck positions on hand grip strength in healthy normal adults.

A cross-sectional, observational study was used to assess the effect of sex and neck positions on hand grip strength in healthy normal adults using the Jamar handheld dynamometer (serial number 30107301; Sammons Preston Company, Leicester, England) and cervical range of motion (CROM, serial number 6512573041; Performance Attainment Associates, Boston, USA). A sample of 100 healthy adults of both sexes participated in this study after approval of the Ethical Committee of the Faculty of Physical Therapy, Cairo University (PT REC/ 012/001190). All participants signed a written consent.

They were assigned into two equal groups according to their sex. Individuals were included if their ages ranged between 17 and 25 years, with a right dominant hand. The exclusion criteria for participants were diagnosis of

cervical radiculopathy, history of any surgery in neck or upper extremity, history of inflammatory joint disease of upper quadrant of the body, and faulty posture of head and neck.

Procedure assessment

Assessment of grip strength for the right dominant hand using Jamar handheld dynamometer

The Jamar handheld dynamometer (Sammons Preston Company) is a small and portable equipment. The dial reads the force in both kilograms and pounds with marking at intervals of 2 kg or 5 lb, allowing the assessment to the nearest 1 kg or 2.5 lb. The calibration accuracy was checked on new machines and the manufactures recommended annual or more frequent calibration [18,19]. The Jamar dynamometer consists of an adjustable handle to accommodate various size hands. The dynamometer handle was adjusted to five grip positions from 13/8 to 33/8 in half increment [20].

Assessment of cervical range of motion

The CROM instrument (Performance Attainment Associates) was shown to be accurate and easily used when two studies compared its validity and reliability over the standard inclinometer measurement on CROM [21]. The CROM has been shown to have some of ratings on inclinometer aspects such as reproducibility, responsiveness, and validity [22].

The study procedure was explained to all subjects. All subjects were instructed to sit in a straight-backed chair with feet flat on the floor, shoulder adducted and neutrally rotated; the elbow joint was flexed at 90°, forearm was in neutral position, and the wrist joint was extended [23]. The CROM was strapped to participants' head and then the participants were asked to place their heads in neutral position and CROM dial was checked for the neutral position to be 0° (Fig. 1). Two magnet bars were placed on the neck anteriorly and posteriorly by soft belt for adjustment of the compass of CROM. A wooden right-angled shape was placed behind the forearm and the arm to keep the elbow joint at right angle during all the tests. All participants were instructed to hold the dynamometer properly in the right dominant hand and apply maximal pressure on the instrument with different neck positions (neutral, flexion, extension, rotation to right, rotation to left, side bending to right, side bending to left) and ask the subjects to complete the full range of motion. All participants were blinded to the dynamometer readings.

Figure 1



Position of subject and handheld dynamometer with CROM. (a) Cervical range of motion device. (b) Magnet belt with its magnet bar for the compass adjustment. (c) HDD, handheld dynamometer. (D) Wooden right angle device to keep right angle of the elbow joint during all tests.

One trial was conducted in each position [24], with a rest period of 1 min in between to minimize fatigue [25]; the length of contraction was maintained for 3 s [14]. The examiner arranged the order of neck position randomly to minimize the effect of fatigue by using the roll dice.

The outcome was measuring grip strength in healthy normal adults, which was measured by using the Jamar handheld dynamometer. The Jamar handheld dynamometer has been demonstrated to be reliable and valid for measuring grip strength by the American Society for Surgery of the Hand [26].

Statistical analysis

All statistical analyses were carried out by using the statistical package for the social sciences (SPSS, version 19 for windows; SPSS Inc., Chicago, Illinois, USA). The Kolmogorov–Smirnov test was used to check the normality of the data. Descriptive statistics and *t*-test were used for comparison of the mean age, height, weight, and body mass index. Two-way analysis of variance test was used to show the difference in grip strength of the dominant hand with different neck position, followed by Bonferoni adjustment for multiple comparisons in case of significance. The level of significance for all statistical tests was set at *P*-value less than 0.05.

Sample size

The sample size estimation was based on power analysis in a pilot study with 20 subjects (mean difference 26.87 and SD 5.64). G*power 3.1 software (University of Dusseldorf, Dusseldorf,

Table 1 Demographic data participants

	Demographic data					
	All participants		Females		Males	
	X	SD	X	SD	X	SD
Age (years)	20.12	1.43	20.28	1.42	20	1.44
Height (m)	1.69	0.07	1.63	0.04	1.75	0.06
Weight (kg)	69.3	10.64	64.15	9.43	74.7	9.12
BMI	24.1	2.94	23.92	3.25	24.3	2.59
Occupation [n (%)]						
Students	80 (80)		42 (84)		38 (76)	
Employee	20 (20)		8 (16)		12 (24)	
Marital status [n (%)]						
Single	92 (92)		45 (90)		47 (94)	
Married	8 (8)		5 (10)		3 (6)	

BMI, body mass index; X, mean.

Germany) was used in the present study. With power 80% and probability 0.05, the sample size of the current study was 100 subjects.

Sample size calculation was carried out on one group (male, female).

Results

A comparison of the demographic data of 100 participants in both groups (50 males, 50 females) revealed no significant differences between the two groups as regards mean age, height, weight, body mass index, occupation, and marital status (Table 1).

Grip strength

There was a significant difference between hand grip strength in seven positions of the neck (neutral, flexion, extension, side bending to right, side bending to left, rotation to right, and rotation to left); *P*-value was less than 0.001, as shown in Table 2 and Fig. 2.

Female hand grip strength

There was a significant difference between hand grip strength in the neutral position and in other neck positions; *P*-value was 0.036, as shown in Tables 3 and 4, and Fig. 2.

Male hand grip strength

There was a significant increase in the hand grip strength from that in the neutral position to those in other neck positions (42.46 ± 7.22). In addition, there were significant differences between the hand grip strength in the flexion position and in all other positions (41.56 ± 7.24). There were significant differences between the hand grip strength in the left side bending position (39.82 ± 6.720) and in the left rotation (40.74 ± 6.77),

and between the hand grip in the right rotation (39.81 ±6.37) and left rotation. *P*-values was less than 0.001, as shown in Tables 3 and 4, and Fig. 2.

Discussion

The purpose of this study was to assess the effect of sex and neck positions on hand grip strength in healthy normal adults. One of the important components in evaluating hand function is the grip strength. It provides an objective index of the functional integrity of the upper extremity and an important component of hand rehabilitation as it is a measure of the therapy effectiveness [27].

This study revealed a significant difference between the mean values of hand grip strength in the neutral

position of the neck and in other neck positions (flexion, extension, right side bending, left side bending, right rotation, and left rotation) for all participants ($P < 0.001$). In the male group, there was a significant difference between the hand grip strength in the neutral position and in other neck positions; within neck positions, there was a significant difference ($P < 0.001$). In the female group, there was a significant difference between the hand grip strength in the neutral position and in other neck positions ($P = 0.036$). There was significant difference between males and females.

An interconnected system of nodes exists between the head and grip of the hand [16]. These connections have direction, strength, and signs, which permit varied degrees of influence between each other.

Table 2 Mean±SD, 95% confidence interval values, and results of comparison of hand grip strength from different neck positions

Hand grip from different neck positions (lb)	Mean±SD (n=100)	95% confidence interval	
		Lower limit	Upper limit
Neutral	34.96±9.46	33.9	36.3
Flexion	34.12±9.38	33.1	35.5
Extension	33.47±9.26	32.3	34.8
Right side bending	33.1±9.01	32.1	34.4
Left side bending	32.98±8.8	31.9	34.3
Right rotation	32.89±8.75	31.9	34.2
Left rotation	33.75±8.95	32.7	35.1
<i>P</i> -value		<0.001*	

*Significant at $P \leq 0.05$.

Table 3 Mean±SD values and results of comparison between hand grip strength from different position

Sex	Grip from neutral (lb)	Grip from flexion (lb)	Grip from extension (lb)	Grip from right side bending (lb)	Grip from left side bending (lb)	Grip from right rotation (lb)	Grip from left rotation (lb)	<i>P</i> -value
Male (n=50)	42.46±7.22	41.56±7.24	40.54±7.28	40.1±6.79	39.82±6.72	39.81±6.37	40.74±6.77	<0.001*
Female (n=50)	27.78±4.42	26.98±4.19	26.70±4.82	26.40±4.81	26.42±4.51	26.26±4.58	27.05±4.58	0.036*

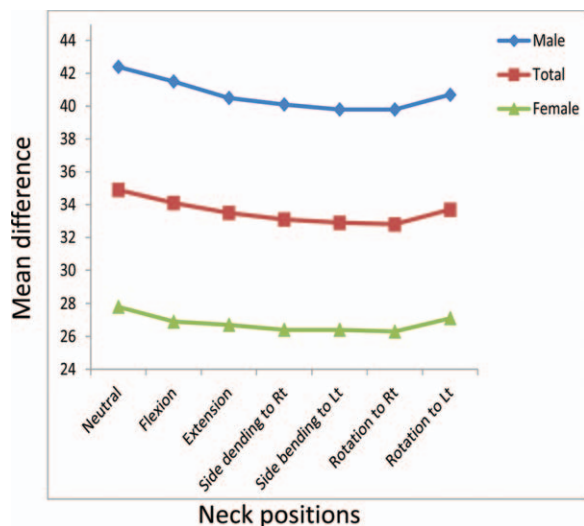
*Significant at $P \leq 0.05$.

Table 4 Mean±SD, 95% confidence interval values, and results of comparison between male and female of hand grip strength from different positions

Hand grip from different neck position (lb)	Male 95% confidence interval			Female 95% confidence interval		<i>P</i> -value	
	Male (n=50)	Lower limit	Upper limit	Female (n=50)	Lower limit		Upper limit
Neutral	42.46±7.22	40.7	44.16	27.78±4.42	26.1	29.5	<0.001*
Flexion	41.56±7.24	39.8	43.2	26.98±4.19	25.3	28.6	<0.001*
Extension	40.54±7.28	38.8	42.3	26.70±4.82	24.9	28.4	<0.001*
Right side bending	40.1±6.79	38.77	41.8	26.40±4.81	24.7	28.1	<0.001*
Left side bending	39.82±6.72	38.2	41.5	26.42±4.51	24.8	28.02	<0.001*
Right rotation	39.81±6.37	38.23	41.4	26.26±4.58	24.7	27.8	<0.001*
Left rotation	40.74±6.77	39.1	42.4	27.05±4.58	25.4	28.7	<0.001*

*Significant at $P \leq 0.05$.

Figure 2



Line chart represent mean of hand grip strength in male and female with different Neck positions.

From a biomechanical point of view, during flexion of the spine there is an increase in the amount of compression force and tension in the nerve root, which affects muscle strength, and there is a decrease in extension [28]. This explains the increase in hand grip strength in flexion and decrease in extension.

According to the vascular system biomechanics, the blood vessels of the spine will deform with postural changes. Arteries and veins will be under tension thus leading to narrowed and increased length of the spinal canal during flexion of the spine; the opposite will be the case during extension of the spine, which will effect the hand grip as there exists an interconnection of nodes between the head and the hand [16,29]. Thus, the hand grip strength increases during neck flexion and decrease during neck extension.

The difference in the hand grip strength with rotation and side bending (either to the right or to the left) is related to the tonic neck reflex. The tonic neck reflex has a symmetrical and an asymmetrical component. The asymmetrical tonic neck reflex (ATNR) pattern involves elbow extension with shoulder abduction on the chin side and elbow flexion with shoulder adduction on the back of head side when the head and neck are rotated [30].

ATNR is normally present during infancy and becomes integrated into the central nervous system at any early age. Once integrated, these reflexes are not generally

recognized in adults in their pure form. These reflexes continue, however, as adaptive fragments of behavior underlying normal motor control [31].

ATNR can be elicited in normal healthy adults along with infants [32], and neurologically impaired person [33]. Bruijn *et al.* [34] reported that the ATNR and symmetrical tonic neck reflex are present in young adults and not only in developing children.

Hand grip strength increased during the rotation of the left side away from the right dominant hand, which is related to ATNR-affected H-reflex of temporal muscles in healthy adults [35]. Deutsch *et al.* [36] suggested that head-neck rotation should be considered when improving the muscle strength of the upper extremity to induce ATNR.

Kumar *et al.* [16] conducted a study to investigate whether head-neck position affects the grip strength in neutral and rotation positions. They concluded that head-neck rotation to the left side away from the right hand dominant may have an increased effect on the hand grip strength. Thus, findings of their study are in agreement with those of the current study that rotation of the left side away from the right dominant hand has an effect on the hand grip strength.

In the current study, the neutral position of the neck showed significant increase in the hand grip strength (neutral to flexion 2.1%, neutral to extension 3.9%, neutral to right side bending 4.9%, neutral to left side bending 5.1%, neutral to right rotation 5.3%, and neutral to left rotation 2.9%). These findings were in disagreement with those by Wong *et al.* [17], who studied the effect of neck positions (neutral, rotation) on upper extremity strength in healthy young women and concluded that there was no influence of head-neck positions on upper extremity strength. That may be due to small sample size (36 women).

For both sexes, there was a significant difference between the hand grip strength in different neck positions; males have been found to have more muscle strength than do females [17].

Further researches are required to investigate the effect of different angles of neck positions on hand grip strength, and also to investigate the effect of facial and neural tension on hand grip strength.

The position of the neck plays an important role in the accurate assessment and rehabilitation approaches of

grip strength accordingly; we can give this advice to the individuals who mainly use the hand grip in their job.

Limitations

A limitation of the current study was the inclusion of a blind investigator, and thus we recommend for further research and also the bias of selection of the sample due to lacking of randomization.

Conclusion

Hand grip strength is affected by changing of the neck position in male and female healthy normal adults. Apparently, the highest grip strength is obtained at the neutral position of neck.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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