International Journal of Research in Medical Sciences
Bisht S et al. Int J Res Med Sci. 2024 May;12(5):1633-1639
www.msjonline.org
pISSN 2320-6071 | eISSN 2320-6012
DOI: https://dx.doi.org/10.18203/2320-6012.ijrms20241253

Original Research Article

Normative values of neck muscle strength in adult population of Delhi NCR region

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Received: 20 March 2024
Revised: 11 April 2024
Accepted: 16 April 2024

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ABSTRACT

Background: The neck pain is common problem in the adult population. Neck muscles have the potential to regulate the neck movement and to maintain its physiological functions and hence should have a quantitative value for strength. The aim of this study was to evaluate the neck muscle strength which would be used as a reference in the analysis of neck pain. Further aim of this study was to analyze the effect of age, weight, height, gender, body mass index (BMI) on muscle strength.
Methods: This study was an observational study conducted at physiotherapy department of I. T. S. Institute of Health and Allied Sciences from 23 September 2023 to 24 February 2024.The study comprised 1200 participants, both male and female, in the age group of 21 to 50 years old. Isometric strength measurements for several neck muscles were made using a handheld dynamometer after ethical approval. Normative strength values were calculated, and multivariate analysis was performed to conclude the effect of age, weight, height, gender and BMI on neck muscle strength. Data analysis was calculated using statistical package for the social sciences (SPSS) version 21.0.
Results: Males are at lower risk than females to develop neck pain as males are having more strength than females in all age groups. Weight and age were positively associated with muscle strength ($p<0.5$). Height and BMI showed no significant correlation to muscle strength ($p>0.5$).
Conclusions: This research provides the normative ranges of neck muscle strength in the adult population that will serve as a baseline and aid in prevention, maintenance and treatment of neck pain. It provides the standard for the clinician to compare the muscle strength of different age groups and unaffected.

Keywords: Neck pain, Muscle strength, Adults, Handheld dynamometer

INTRODUCTION

Neck pain is a multifactorial and common problem in the adult population and has continually increased in recent times.[1] The prevalence of neck pain in the world-wide range ranges from 16.7% to 75%.[2] A few population-based studies have explained the role of various risk factors and etiology, such as age, body weight, neck musculoskeletal condition, incorrect neck and body posture, neck muscle dysfunction are the factors for neck, shoulder and scapular pain.[1-3] Some studies have shown a relationship between neck pain, and risk factors, that directly affect the quality of life and result in other physical pain and discomfort that can be a causing agent for shoulder and scapular pain.[4,5] Neck structure involves the major neck muscles group, which are the neck flexors muscle group (platysma, sternocleidomastoid, subclavius, scalene, suprahyoid and infrahyoid muscles), neck extensors muscle group (splenius capitis, splenius cervicis, suboccipital, transverse spinal muscles), neck side flexors muscle group (rectus capitis anterior, rectus capitis longus, longus capitis, longus colli).[6,7] And these muscles have a potential

strength that helps to regulate the specific anatomical and physiological function of the neck and hence strength of neck muscles is necessary for neck activities and to maintain the physiological and morphological functions of the cervical region and should have quantitative strength values.[8] Few studies have reported the association between neck pain and reduced neck muscle strength due to aging factors and shows that strength plays an important role in rehabilitation, such as to evaluate progress, to set the goal, to compare strength between the limbs or sides and to reduce the inflammatory process.[9,10] Altered activation of muscles leads to muscle dysfunction, which causes poor muscle force production and other physical discomforts, so appropriate strength for these muscles should be maintained.[11,12] Old studies reported normative values for neck strength, but they were restricted to specialized groups of individuals and small sample size.[4,10,13,14] Some of them have not shown the effect of age, weight, height, gender, body mass index (BMI) on neck muscle strength.[7,8,10,13,14] Few researchers used manual muscle testing, break test and make test techniques to measure strength but the normative outcomes were affected with these tests as they have poor intra-rater and inter-rater reliability.[15] In this research, the muscle strength was measured with the help of MicroFET handheld dynamometer (HHD) which is a reliable and valid tool that offers clinicians a means for objectively assessing muscle force production (muscle strength).[16-18] This research was to evaluate the isometric neck muscle strength which would be used as a reference in the risk analysis of neck pain and to cure, maintain, prevent and reduce the pain. Further aim of this research was to analyze the effect of age, weight, height, gender, BMI on neck muscle strength. This study will provide the standard for the clinician to compare the muscle strength of different age groups and unaffected pain-free limbs can be used for strength measurement. This study will be helpful to clinicians for rehabilitation in order to compare strength, to record progress and to set up the training program. This data will serve as a reference for theoretical and clinical studies as well as future research investigations.

METHODS

This observational study tested normative strength ranges using the healthy and young adult population of Delhi NCR region. From 23 September 2023 to 24 February 2024, a total of 1,200 samples were collected through a series of camps held at the physiotherapy department of the OPD of the I. T. S. Institute of Health and Allied Sciences, Ghaziabad. IIEC/2021-23/PHYSIO/031 is the approval ID number approved by the local ethical committee, I. T. S. Institute of Health and Allied Sciences, Ghaziabad, India.

Inclusion criteria

Participants selection was based on inclusion criteria (aged between 21 and 50 years, both genders, without any neck, shoulder and scapular impairments).

Exclusion criteria

Participants were excluded if they have any of the following (complaint of neck/scapular/shoulder pain, history of pregnancy, cancer, spinal surgery, cervical surgery, disc pathology with or without radicular symptoms, tuberculosis of spine, shoulder and neck pathology, inflammatory, rheumatoid disease, any medical diagnosis of systematic, muscular and connective tissue disorders).

Testing position, duration (30 minutes for the entire testing process) and procedures were explained to participants for smooth completion of the research. Participants were divided according to the age group (21-30, 31-40 and 41-50 years) and a consent form was signed by each before proceeding with the study.[14,18-20] Weight (by weighing machine), height (by stadiometer) and general demographic information (name, age, gender, dominant hand, occupation, phone number, address, pain history, any difficulties in activities of daily living, medical and surgical history) was documented.[15,18,19,21] Subjects were positioned on an adjustable treatment table.[22] Two non-elastic belts with velcro were used to prevent any compensatory movements of the other parts of the body.[15,20-22] Maximum isometric contraction was measured using a calibrated MicroFET handheld dynamometer tool in four positions that includes neck flexion at 30°, neck extension at neutral, neck right side flexion at neutral and neck left side flexion at neutral.[4,13,21-24] Those testing positions were randomized by using the random number generator.[15,20,22-24] Participants were asked to perform maximum isometric contraction for three seconds against the HHD and by maintaining the head position. For each neck muscle group testing and head position placement, the subjects were instructed and encouraged to perform three consecutive trials and the peak forces (in Newton) were measured during each repetition.[4-24] The average of all three trials was considered to be the subject's isometric neck strength, which was used for normative data and analysis. Few research studies have shown the effect of normalizing muscle strength using anthropometric parameters and explained body weight as an effective parameter, in 2011 and 2023.[25,26] Muscle strength was normalized to body weight (Newton of force/body weight in kg) in comparison to the strength between the population and subjects. Muscle strength ranges for both genders and for the population was evaluated.

Testing position for each neck muscles group

Neck flexors muscle group

Subject was in supine, lying with arms on the side and a Velcro strap was tied at chest level to prevent any compensatory body movements from the trunk during the test. The therapist was standing behind the subject's head with straight arms and applied a force in the direction of extension by placing the HHD at the middle of the subject's

head. The subject was asked to tuck their chin in and push their head with maximum isometric contraction maintaining at 30° neck flexion against the HHD for three seconds (Figure 1).[4,7,13,15,18-23,27-29]

Neck extensors muscle group

Subject was in a prone position with arms at the side and shoulders supported at the edge of the testing table with the head beyond the edge. A Velcro strap was tied at the upper back level for stabilization and to prevent any compensatory body movements. The therapist was standing behind the subject's head with straight arms and applying force in the direction of neck flexion. The subject was asked to perform an isometric neck extension in a neutral position for three seconds against the HHD that was placed at the center and behind the subject's head (Figure 2).[4,7,13,15,18-24,27-29]

Neck side flexion muscle group

Subject was in the supine position with arms at the side and a Velcro strap was tied at the shoulder level to stabilize and to prevent any compensatory body movements from the trunk during the test. The therapist was standing at the side of the subject's head with straight arms and applied force in the opposite direction of the testing side. The subject was instructed to tuck their chin in and hold their head to side flexion with maximum isometric contraction in a neutral position for three seconds against the HHD that was placed at the center of the subject's side. This testing position was performed on the right and left neck side flexion (Figure 3).[4,7,13,15,18-23,27-29]

Statistical analysis

Mean and standard deviation (SD) for demographic data were calculated using the 95% CI method and for each muscle group, calculated using the strength normalization formula (normalization of strength by body weight (in N/kg) that was stratified by age (21-30, 31-40, 41-50 years), gender, height, weight and BMI. Pearson's correlation method was used to determine the relation between BMI, age, gender, height, weight and muscle strength. The t-test was used to determine a muscle strength comparison between genders along with the age groups.

RESULTS

The mean and SD of the subject's demographic along with the normalized muscle strength stratified by age, BMI, height, and weight for both genders (Tables 1-4). Each table shows that as the age increases the neck muscle strength decreases in both genders. Males (M) always have higher strength than females (F) in each age decade. Results also show a significant correlation between muscle strength, age, gender and weight, which implies that as weight and age increases so the muscle strength changes. It shows poor correlation between BMI, height and neck muscle strength (Table 5) which shows there is no impact of BMI and height on strength.

Table 1: Mean and SD of normalized strength (N/kg) and demographic data based on age decades along with gender.

Vari-ables	Overall sample				21-30 years		31-40 years		41-50 years		
	Total (n=1200)	F (n=600)	M (n=600)	P value	F (n=200)	M (n=200)	F (n=200)	M (n=200)	F (n=200)	M (n=200)	P value
Age (in years)											
Mean	35.43	35.52	35.34	0.71	25.54	25.29	35.79	35.66	45.23	45.06	<0.001
SD	8.55	8.53	8.56		2.83	2.68	2.87	2.88	2.83	2.96	
Height (cm)											
Mean	163.44	157.74	169.13	<0.001	156.86	168.65	158.48	169.74	157.87	169.00	0.08
SD	8.46	6.38	6.13		5.69	6.82	7.25	5.75	6.01	5.74	
Weight (kg)											
Mean	76.99	81.86	72.11	<0.001	79.56	71.59	82.40	72.94	83.61	71.81	<0.001
SD	7.93	6.83	5.63		7.84	5.03	5.96	6.34	5.88	5.38	
BMI											
Mean	29.13	32.99	25.26	<0.001	32.38	25.24	32.97	25.37	33.63	25.17	0.21
SD	4.75	3.22	2.18		3.27	2.19	3.41	2.48	2.86	1.82	
Neck flexor											
Mean	0.68	0.61	0.75	<0.001	0.66	0.76	0.63	0.76	0.56	0.72	<0.001
SD	0.10	0.07	0.06		0.08	0.06	0.06	0.07	0.05	0.06	
Neck extensor											
Mean	0.91	0.82	1.00	<0.001	0.96	1.20	0.80	0.88	0.69	0.91	<0.001
SD	0.17	0.14	0.16		0.11	0.09	0.06	0.08	0.06	0.07	
Right neck flexor											
Mean	0.77	0.70	0.85	<0.001	0.73	0.92	0.67	0.85	0.69	0.78	<0.001
SD	0.11	0.07	0.09		0.08	0.07	0.06	0.07	0.06	0.06	

Continued.

Vari-ables	Overall sample				21-30 years		31-40 years		41-50 years		
	Total (n=1200)	F (n=600)	M (n=600)	P value	F (n=200)	M (n=200)	F (n=200)	M (n=200)	F (n=200)	M (n=200)	P value
Left neck flexor											
Mean	0.77	0.69	0.84	<0.001	0.73	0.91	0.67	0.84	0.68	0.77	<0.001
SD	0.11	0.07	0.09		0.08	0.07	0.06	0.07	0.06	0.06	

P values show the strength comparison between both male and female, *statistically significant difference p<0.001

Table 2: Mean and SD of normalized strength (n/kg) and demographic data based on BMI along with gender.

Vari-ables	Overall sample				15-20 kg/m^2	20-25 kg/m^2		25-30 kg/m^2		30-35 kg/m^2		
	Total (n=1200)	F (n=600)	M (n=600)	P value	M (n=2)	F (n=2)	M (n=299)	F (n=110)	M (n=281)	F (n=488)	M (n=18)	P value
Age (in years)												
Mean	35.43	35.52	35.34	0.71	33.50	31.00	35.60	33.54	35.22	35.98	33.00	0.26
SD	8.55	8.53	8.56		3.54	7.07	8.70	8.13	8.61	8.57	5.30	
Height (cm)												
Mean	163.44	157.74	169.13	<0.001	179.80	168.65	171.53	162.34	166.92	156.66	162.62	<0.001
SD	8.46	6.38	6.13		0.00	9.41	5.19	7.57	5.96	5.53	5.19	
Weight (kg)												
Mean	76.99	81.86	72.11	<0.001	61.35	67.40	69.35	74.73	74.51	83.53	81.74	<0.001
SD	7.93	6.83	5.63		0.00	11.75	4.22	7.21	5.19	5.50	4.57	
BMI												
Mean	28.86	32.46	25.26	<0.001	18.98	23.58	23.57	28.31	26.74	33.44	30.90	<0.001
SD	4.31	2.55	2.18		0.00	1.50	1.00	1.20	1.23	1.59	0.64	
Neck flexor												
Mean	0.68	0.61	0.75	<0.001	0.90	0.81	0.77	0.68	0.72	0.60	0.67	<0.001
SD	0.10	0.07	0.06		0.00	0.13	0.06	0.09	0.05	0.06	0.04	
Neck extensor												
Mean	0.91	0.82	1.00	<0.001	1.04	1.06	1.03	0.93	0.97	0.79	0.88	<0.001
SD	0.17	0.14	0.16		0.00	0.26	0.16	0.16	0.16	0.12	0.17	
Right neck flexor												
Mean	0.77	0.70	0.85	<0.001	1.01	0.85	0.88	0.77	0.82	0.68	0.77	<0.001
SD	0.11	0.07	0.09		0.00	0.17	0.08	0.08	0.08	0.05	0.07	
Left neck flexor												
Mean	0.77	0.69	0.84	<0.001	0.99	0.86	0.87	0.76	0.81	0.68	0.75	<0.001
SD	0.11	0.07	0.09		0.00	0.18	0.08	0.08	0.09	0.05	0.06	

P values show the strength comparison between both male and female, *statistically significant difference p<0.001

Table 3: Mean and SD of normalized strength (n/kg) and demographic data based on height along with gender.

Varia bles	Overall sample				140-150 cm	150-160 cm		160-170 cm		170-180 cm		180-190 cm	
	Total (n=1200)	F (n=600)	M (n=600)	P value	F (n=68)	F (n=335)	M (n=50)	F (n=171)	M (n=294)	F (n=26)	M (n=238)	M (n=18)	P value
Age (in years)													
Mean	35.43	35.52	35.34	0.71	35.68	35.36	34.18	35.38	35.80	38.04	35.32	31.11	0.26
SD	8.55	8.53	8.56		7.48	9.04	9.30	8.02	8.88	7.60	7.94	8.44	
Height (cm)													
Mean	163.44	157.74	169.13	<0.001	147.78	155.57	156.84	163.58	166.62	173.23	173.85	181.89	<0.001
SD	8.46	6.38	6.13		2.25	2.65	2.47	2.61	2.63	2.26	3.21	2.03	
Weight (kg)													
Mean	76.99	81.86	72.11	<0.001	76.98	81.74	68.33	83.57	70.64	85.00	74.43	75.85	<0.001
SD	7.93	6.83	5.63		8.43	6.59	4.89	5.81	5.01	4.59	5.46	5.46	
BMI													
Mean	29.13	32.99	25.26	<0.001	35.26	33.79	27.80	31.25	25.47	28.35	24.65	22.93	<0.001
SD	4.75	3.22	2.18		3.84	2.79	2.10	2.33	1.97	1.79	1.97	1.65	
Neck flexor													
Mean	0.68	0.61	0.75	<0.001	0.66	0.61	0.78	0.60	0.76	0.59	0.73	0.72	<0.001
SD	0.10	0.07	0.06		0.09	0.07	0.06	0.06	0.06	0.05	0.06	0.06	

Continued.

Variables	Overall sample				140-150 cm	150-160 cm		160-170 cm		170-180 cm		180-190 cm	
	Total (n=1200)	F (n=600)	M (n=600)	P value	F (n=68)	F (n=335)	M (n=50)	F (n=171)	M (n=294)	F (n=26)	M (n=238)	M (n=18)	P value
Neck extensor													
Mean	0.91	0.82	1.00	<0.001	0.88	0.82	1.09	0.80	1.02	0.75	0.95	1.01	<0.001
SD	0.17	0.14	0.16		0.17	0.14	0.17	0.12	0.16	0.08	0.15	0.15	
Right neck flexor													
Mean	0.77	0.70	0.85	<0.001	0.75	0.70	0.90	0.68	0.86	0.66	0.82	0.84	<0.001
SD	0.11	0.07	0.09		0.09	0.07	0.10	0.06	0.09	0.04	0.09	0.08	
Left neck flexor													
Mean	0.77	0.69	0.84	<0.001	0.74	0.70	0.89	0.68	0.85	0.66	0.81	0.83	<0.001
SD	0.11	0.07	0.09		0.10	0.07	0.09	0.06	0.09	0.04	0.09	0.08	

P values show the strength comparison between both male and female, *statistically significant difference p<0.001

Table 4: Mean and SD of normalized strength (n/kg) and demographic data based on weight along with gender.

Vari-ables	Overall sample				50-60 kg	60-70 kg		70-80 kg		80-90 kg			
	Total (n=1200)	F (n=600)	M (n=600)	P value	F (n=1)	M (n=2)	F (n=36)	M (n=265)	F (n=182)	M (n=280)	F (n=381)	M (n=53)	P value
Age (in years)													
Mean	35.43	35.52	35.34	0.71	26.00	29.00	30.08	35.74	34.49	34.60	36.55	37.42	<0.001
SD	8.55	8.53	8.56			7.07	7.68	9.03	8.48	8.40	8.40	6.47	
Height (cm)													
Mean	163.44	157.74	169.13	<0.001	162.00	160.15	151.56	167.36	156.58	170.23	158.86	172.55	<0.001
SD	8.46	6.38	6.13			4.17	4.93	5.92	6.15	5.97	6.19	5.05	
Weight (kg)													
Mean	76.99	81.86	72.11	<0.001	59.09	56.83	66.26	67.17	75.91	74.75	86.24	83.41	<0.001
SD	7.93	6.83	5.63			1.95	2.77	2.12	2.78	2.60	2.91	2.30	
BMI													
Mean	29.13	32.99	25.26	<0.001	22.52	22.16	28.92	24.06	31.09	25.88	34.31	28.08	<0.001
SD	4.75	3.22	2.18			0.40	2.11	1.72	2.59	1.86	2.73	1.80	
Neck flexor													
Mean	0.68	0.61	0.75	<0.001	0.90	0.97	0.77	0.80	0.66	0.72	0.58	0.65	<0.001
SD	0.10	0.07	0.06			0.03	0.07	0.04	0.04	0.04	0.05	0.03	
Neck extensor													
Mean	0.91	0.82	1.00	<0.001	1.24	1.34	1.08	1.07	0.89	0.97	0.76	0.80	<0.001
SD	0.17	0.14	0.16			0.34	0.13	0.15	0.11	0.13	0.09	0.09	
Right neck flexor													
Mean	0.77	0.70	0.85	<0.001	0.97	1.14	0.87	0.91	0.75	0.82	0.66	0.72	<0.001
SD	0.11	0.07	0.09			0.11	0.05	0.07	0.04	0.06	0.03	0.05	
Left neck flexor													
Mean	0.77	0.69	0.84	<0.001	0.98	1.12	0.86	0.89	0.74	0.81	0.65	0.71	<0.001
SD	0.11	0.07	0.09			0.12	0.05	0.08	0.04	0.06	0.03	0.05	

P values show the strength comparison between both male and female, *statistically significant difference p<0.001

Table 5: Correlation between variables and normalized strength for both genders.

Variables	Neck flexor	Neck extensor	Right neck flexor	Left neck flexor
Male				
Age	-0.23	-0.61	-0.61	-0.63
BMI	-0.53	-0.33	-0.43	-0.43
Height (cm)	-0.32	-0.25	-0.24	-0.24
Weight (kg)	-0.88	-0.57	-0.71	-0.69
Female				
Age	-0.5	-0.8	-0.2	-0.27
BMI	-0.53	-0.44	-0.54	-0.56
Height (cm)	-0.21	-0.18	-0.29	-0.25
Weight (kg)	-0.81	-0.66	-0.92	-0.91

DISCUSSION

This study was to analyze the neck muscle strength data across a wide range of age groups in healthy adults. Age, gender, height, weight, BMI were the variables used to find how they are related to the neck muscle strength measures and how strength variation leads to pain risk.

Findings in this study suggested that gender, weight and age were significantly associated with neck strength whereas no association was found between height and BMI.

Effect of gender and body weight on muscles strength

Neck strength is affected by gender, and was studied by many researchers. Males have more muscle strength than females in all tested neck positions and in all age groups and hence were at lower risk to pain than females. Normalization of data showed body weight is the most effective parameter in terms of variability and reason for pain. It is observed that the findings of this research are due to differences in muscle mass, muscle morphology and bone density between male and female.[13,25,26,30,31-35]

Effect of height and BMI on muscles strength

BMI was not a significant factor for neck strength measurements between gender and in age decades. It shows a poor relationship to neck muscle strength and hence cannot be a risk factor for neck pain.

BMI doesn't affect muscle mass and morphology, hence body movements regulated by muscle remain intact as described in studies.[25,26,30-32]

Effect of age on muscles strength

This study concluded that age has positive effects on neck muscle strength and increases the risk of neck pain, inflammatory and rheumatological conditions. Degenerative aging process, loss of muscle mass, reduced physical activity along with increased age have a positive impact on neck muscle strength and their neck functions. With respect to gender, aged males have more strength than aged females, but muscle strength reduces as the male and female ages.[18,20,25,30-35]

Limitations

One of the limitations of this research was the potential for selection bias of participants. The population was taken majorly from Delhi NCR region. Future research studies should include a wide range of populations and locations. The younger population and upper age range (above 50 years) was not included in this study. Inclusion of other age groups would have added more information about strength changes with age. Further, this research used verbal methods for documentation of pain, medical and surgical history to determine the neck and subject's health. A physical examination which could examine asymptomatic neck, shoulder and scapular pathology was not used.

CONCLUSION

The outcome of this research has provided a normative baseline for the normal and healthy adult population across three decades. This study shows the evidence that healthy subjects without any pathologies have standard strength values. The resulting neck strength data is age, weight and gender dependent and decrease in the strength can increase the risk of neck, shoulder and scapular pain. This reference data will help the clinicians to set goals, record progress, analyze risk factors and to change treatment protocol during rehabilitation.

ACKNOWLEDGEMENTS

The authors would like to thank all those who have supported for the completion of this research study.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Bisht S, Chaudhuri S, Thangaraj M, Ram CS. Normative values of neck muscle strength in adult population of Delhi NCR region. Int J Res Med Sci 2024;12:1633-9.