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Evaluating Cervical Core Muscle Strength in Various Age Groups among Normal Individuals

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1. Introduction

Problem Statement: The Burden of Neck Pain

Musculoskeletal disorders are the second main contributor to global years lived with disabilities (YLDs). The specific major musculoskeletal disorders that are leading contributors to YLDs globally are low back pain and neck pain.(1)In 2020, the estimated total number of people (all ages) living with neck pain was 203 million globally, which is a 77.3% increase from 115 million in 1990. The global age-standardised prevalence rate of neck pain was 2,450 per 1,00,000 in 2020 (Figure 1). (2)Overall, the annual prevalence of neck pain in the workforce and general community individuals ranges from 30% - 50%.(3)

The cervical flexors, primarily the deep neck flexors (DNF) (longus capitis, longus colli, rectus capitis anterior and lateralis), are postulated to assist in stabilizing the cervical spine during gross neck movements.(4,5) Results of recent studies indicate that patients with a history of cervical spine pain demonstrate a delay in neck flexors(NF) activation when associated with use of the arm, which indicates a significant deficit in the automatic feedforward control of the cervical spine.(06) This delayed response may leave the cervical spine vulnerable to reactive forces (unexpected outside forces), thus contributing to cervical spine nonradiologically appreciable, clinical instability, or impairment when the extremities move in space during functional activities throughout the day, such as reaching or placing objects. This compromise in NF control may lead to cervical spinal dysfunction, where a cycle of pain and weakness is established.(5,7,8)

Moreover, NF weakness and endurance deficits appear to correspond with the inability to sustain craniocervical flexion in an inner-range position, where craniocervical flexion produces upper cervical spine and cranium forward nodding in response to the deep cervical flexor muscles that structurally support cervical motion segments. This control deficit is associated with increased cervical spine lordosis and serves as a contributor to the pathogenesis of head and/or neck pain.(7,8) Cervical spine function is directly influenced by cervical flexor function e.g. cervical core muscle strength and endurance. Any challenge to cervical spine flexor strength and endurance activity could lend to cervical dysfunction, tissue overload, trauma, and pain (4).

Keywords: CCFT, DNF, Cervical core muscle Strength, Normative

2. Need of the Study

Presently, there are no specific protocols or normative data for evaluation of cervical muscle activation score/ strength. An appropriate and reliable protocol for non-instrumented testing of DNF muscle endurance provides a valuable asset to the clinician involved in prevention and management of neck pain. Clinical guidelines for neck pain include the DNF test as an important component in cervical spine examination. In line with the International Classification of Functioning, Disability, and Health, this test can be used when classifying a patient in the impairment-based category for neck pain with headaches and neck pain with movement coordination impairments.(9)

Thus, there is a need to establish a normative database for the cervical muscle strength to a person's age and gender. Such a database would provide clinicians and their clients with a baseline for establishing and monitoring programs designed to increase cervical flexor strength and endurance. So, the purpose of the study was to establish normative data for cervical core muscle strength.

Aim of the Study

To find out the normative data for cervical core muscle strength

Objectives of the Study

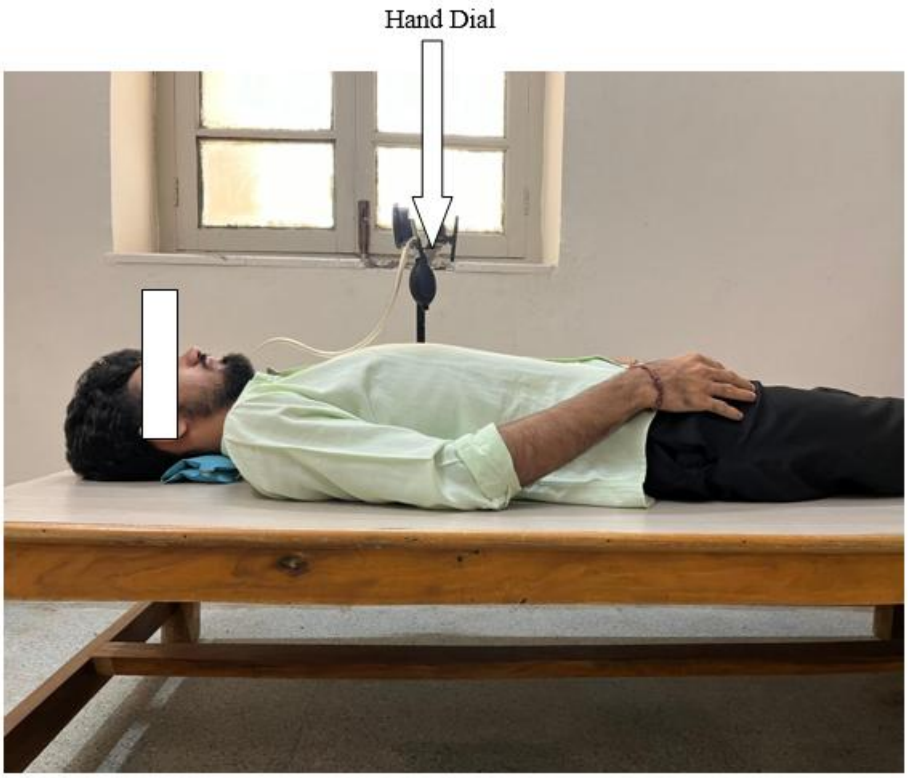
1) Primary Objectives:
    - To compare the normative value between male and female
    - To find out the normative value in different age groups
2) Secondary Objectives:
    - To create a baseline value for patients with neck pain or to set a goal for neck pain patients

3. Methods and Materials

Methods

Subjects were taught to perform the Cranio-cervical flexion test passively. Then subject was positioned in supine lying position. The cervical spine was supported in a neutral position which was determined visually by maintaining a horizontal plane between the forehead and chin. The pressure biofeedback unit was placed between the plinth and the posterior aspect of the neck just below the occiput and inflated to a baseline of 20 mm of Hg. Subjects were given sufficient time to practice the cranio-cervical flexion movement with the pressure biofeedback unit. Any substitution movement was observed and corrected to ensure that all subjects could perform the test correctly. Sign of incorrect performance, such as posterior retraction of the chin to push the neck directly back onto the sensor, were corrected by the trained examiner during the practice phase. The examiner closely monitored subjects during the CCFT and superficial neck flexor muscles recruitment was discouraged by verbal feedback. Each subject was reminded to relax the neck musculature and to concentrate on performing a gentle, nodding head movement. Each subject was instructed to perform the cranio-cervical flexion movement at maximum pressure levels (20-30) mmhg and to hold each level for 10 seconds. A 30 seconds rest period was provided between each level. Between each trial 1min rest was given. Three trials were given. The highest level each subject achieved was recorded.

The hand dial of the pressure sensor was mounted on a stand to provide the subject with visual feedback to target the desired pressure levels during testing.



Study Area: Govt. Physiotherapy College,Jamnagar

Study Design: Observational analytical study; Cross-sectional study

Sample Size:
The sample size required for this study was calculated based on a pilot study done among 10 males and 10 female of 20 to 60 years.

The activation index (AI) and performance index (PI) were measured among these 20 healthy individuals. It was found that mean AI of these 20 healthy males and females was 29.70 with an SD of 5.26. The mean PI of the pilot group was 63.00 with an SD of 29.17.

The required sample size was calculated based on the following formula(76) :

$$\text{Sample size} = \frac{{Z_{1-\alpha/2}}^2 \, SD^2}{d^2}$$

Where,
$Z_{1-\frac{\alpha}{2}}$ = Value of Std. normal deviate for value of α (type I error),
SD = Standard deviation,
d = Absolute error or precision around the mean, i.e. the range around the mean within which we want to have for best estimate of a measurement.

For this study, the sample size was calculated to AI and PI separately as follows:

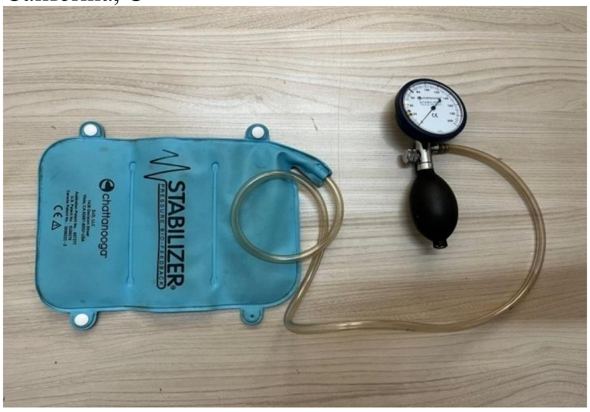
Sample size required for estimation of AI:
Taking mean AI of 29.70 with an SD of 5.26 based on pilot study, α error (or type I error) at 5%, giving 95% confidence level (with corresponding value of std. normal deviate '$Z_{1-\alpha/2}$' of 1.96), and absolute precision (d) of 1, **the sample size required is 107.**

Sampling: Random sampling

Inclusion Criteria
- Age group: 20 - 60 years healthy individuals.
- Gender: Both male and female
- Who have Muscle power grade 4 and 5(MRC grading)
- Willingness to participate in the study as a volunteer
- No cervical pain or any symptom since last 6 month.

Exclusion Criteria
- Patient who are unwilling to participate
- Those who are not able to understand and perform the testing procedure.
- A heart condition that precluded performing the exercises.
- Patients with cervical myelopathy
- Patients with cervical disc prolapse
- Patients with spinal tumors
- Patients with spinal infection
- Previous spinal surgery
- Vertebro-Basilar Insufficiency (VBI)
- Any musculoskeletal problem such as AS, RA and deformity or trauma around neck.
- Pregnant women

Instruments Used
- Pressure Biofeedback Unit (StabilizerTM, Chattanooga, California, U



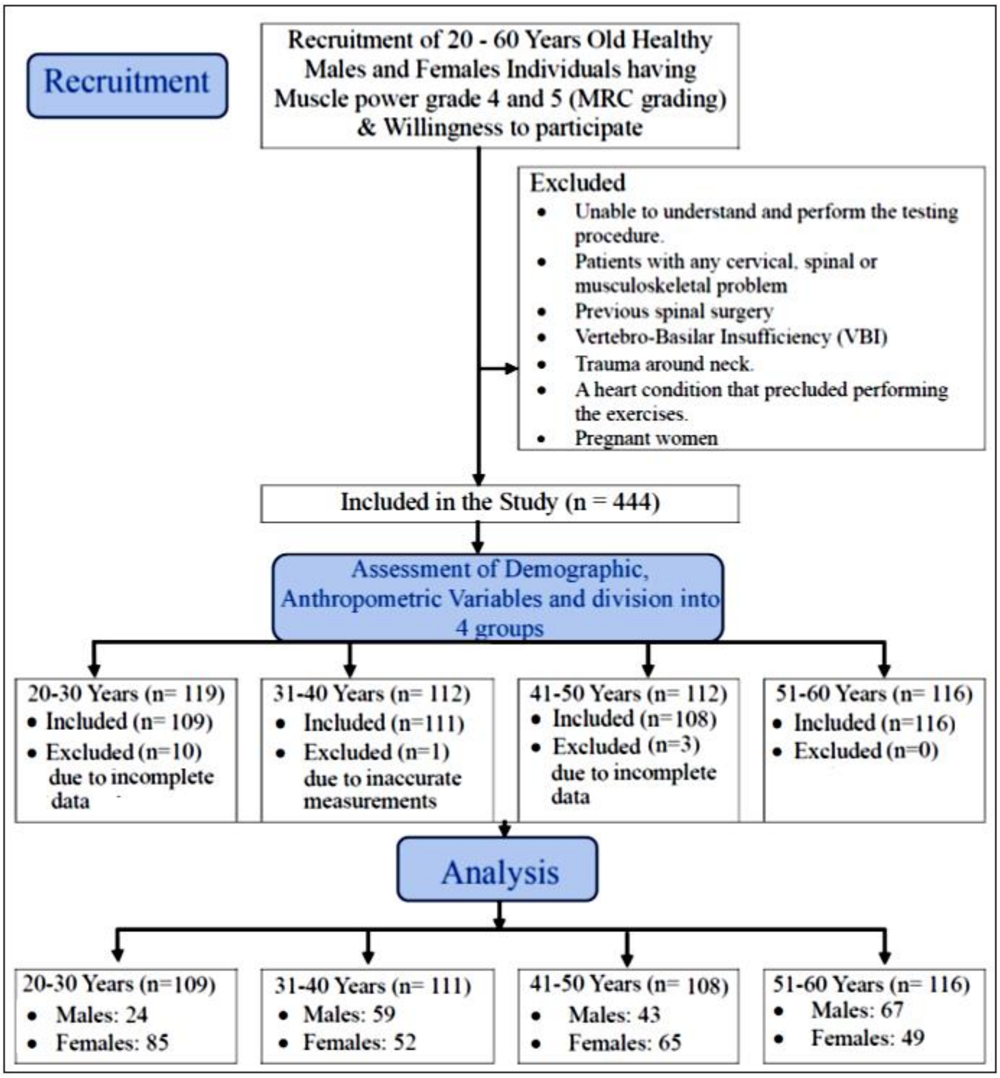
- Standard Weighing Scale
- Stadiometer

Materials used
- Hard surface plinth
- Stop watch
- Data Collection sheet
- Paper
- Pen

Procedure
Subjects were selected for the study as per the inclusion criteria from the city of Jamnagar, Gujarat, India. Subjects were called for the study through mouth to mouth publicity. Then onthe basis of inclusion and exclusion criteria final subjects participated in the study. Each subject filled out the Subject Information sheet and signed informed consent form (in vernacular language if needed). Demographic data such as age and gender was taken of the subject.

4. Analysis and Results

Design and Flow of Participants through the Study



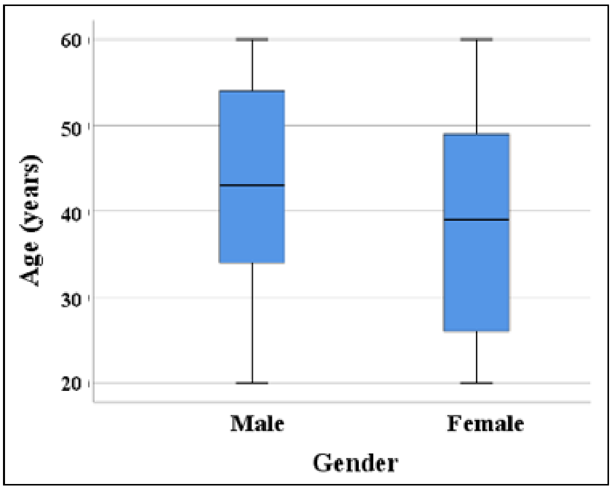
The demographic and anthropometric variables were assessed for the included participants and they were divided into four age groups. In the 20-30 years group, 119 individuals were recruited, with 109 included in the final analysis and 10 excluded due to incomplete data. The 31-40 years group had 112 participants, with 111 included and 1 excluded due to inaccurate measurements. The 41-50 years group initially had 112 participants, but 3 were excluded due to incomplete data, leaving 108 for analysis. The 51-60 years group had 116 participants, all of whom were included in the study.

In the 20-30 years group, there were 24 males and 85 females. The 31-40 years group had 59 males and 52 females, while the 41-50 years group included 43 males and 65 females. The 51-60 years group had 67 males and 49 females. The final analysis was performed to assess normative values of Activation Score (AS) for cervical core muscles which were reported age-wise and gender-wise.

Overall Age and Age Distribution according to Gender

S. No.	Gender	Minimum-Maximum	Mean (SD)	Median (IQR)
1	Male	20- 60	43.03 (11.45)	43 (34- 54)
2	Female	20- 60	38.39 (12.41)	39 (26- 49)
	Overall	20- 60	40.41 (12.21)	41 (31- 51)

The box plot in the following graph shows minimum and maximum ages with median and IQR for the males and females.



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Age Group wise Gender Distribution

S. No.	Age Group	Gender				Total	
		Male	%	Female	%	n	%
1	20-30 Years	24	12.44%	85	33.86%	109	24.55%
2	31-40 Years	59	30.57%	52	20.72%	111	25.00%
3	41-50 Years	43	22.28%	65	25.90%	108	24.32%
4	51-60 Years	67	34.72%	49	19.52%	116	26.13%
	Total	193	100.00%	251	100.00%	444	100.00%
$\chi 2$ = 34.87, $\delta\phi$=3, π<0.001							

Overall and Gender wise Activation Score

Descriptive Statistics of Overall and Gender wise Activation Score (mmHg)

S. No.	Gender	Minimum-Maximum	Mean (SD)	Median (IQR)
1	Males (n=193)	2 - 10	9.04 (2.12)	10 (10 - 10)
2	Females (n=251)	2 - 10	8.92 (2.32)	10 (10 - 10)
	Overall (n=444)	2 - 10	8.97 (2.23)	10 (10 - 10)

Normative Values of Overall and Gender wise Activation Score (mmHg)

S. No.	Gender	Lower Limit (90% CI)	Upper Limit (90% CI)	Reference Range
1	Males (n=193)	2 (0.00 to 4.00)	10 (10.00 to 10.00)	2 - 10
2	Females (n=251)	1.3 (0.00 to 4.00)	10 (10.00 to 10.00)	1.3 - 10
	Overall (n=444)	2 (0.00 to 2.00)	10 (10.00 to 10.00)	2 - 10

Descriptive Statistics of Activation Score (mmHg) according to the Age Group

S. No.	Gender	Minimum-Maximum	Mean (SD)	Median (IQR)
1	20-30 Years (n=109)	4 - 10	9.78 (0.84)	10 (10 - 10)
2	31-40 Years (n=111)	2- 10	9.05 (2.14)	10 (10 - 10)
3	41-50 Years (n=108)	2- 10	8.99 (2.17)	10 (8.5 - 10)
4	51-60 Years (n=116)	2- 10	8.12 (2.89)	10 (6 - 10)
1	20-30 Years (n=109)	4 - 10	9.78 (0.84)	10 (10 - 10)

5. Discussion

In addition to creating a reference database for Gujarati rural populations, the current study sought to establish normative data for cervical core muscle function, with an emphasis on comparing values across gender and age groups. In clinical practice, normative values are crucial because they provide a starting point for determining deficiencies in the strength, endurance, or function of the cervical muscles, especially in patients who present with neck pain. By establishing such values in a variety of populations, physicians can use culturally and regionally appropriate standards to improve diagnostic precision and direct rehabilitation tactics.

Saini, Singh, and Kothiyal (2024) recently added to the literature by assessing normative values of deep neck flexor muscle strength using pressure biofeedback units and sphygmomanometers, building upon these developmental and regional perspectives. Their results showed the clinical usefulness and dependability of inexpensive, basic instruments for assessing cervical muscle function, opening the door to normative evaluation in environments with limited resources. Because the current study focuses on rural Gujarat, where advanced dynamometry might not always be available, this aspect is especially relevant. The external validity and applicability of the data are improved by the use of readily applicable and reasonably priced tools, which guarantee that normative values can be converted into practice across various healthcare settings. The work of Saini et al. also emphasizes how crucial methodological consistency is to developing strong normative benchmarks, since variations in testing procedures can lead to study variability.

From a methodological standpoint, the assessment of cervical muscle strength has also been investigated. Using a modified sphygmomanometer dynamometer, Vernon, Aker, Aramenko, Battershill, Alepin, and Penner (1992) assessed neck muscle strength, proving validity and reliability in evaluating cervical musculature. This early study, which came before more advanced approaches, was essential in demonstrating the potential of affordable devices for muscle assessment. Vernon et al.'s work is relevant to the current study because it shows that standardized, straightforward methods of evaluating strengths can yield accurate data that can be used to establish normative values. The application of such proven, affordable methods is even more crucial in rural areas where cutting-edge technology might not be easily accessible. Their study also shows how foundational approaches continue to impact clinical research in cervical muscle function, adding historical continuity to the current body of evidence.

More recently, Krause, Hansen, Hastreiter, Kuhn, Peichel, and Hollman (2018) used handheld dynamometers to compare different cervical muscle strength testing techniques. Their study brought to light disparities among various evaluation instruments and underscored the significance of choosing valid and dependable techniques for use in clinical and research settings. Because it emphasizes the necessity of consistency when establishing normative data, the comparison of testing methods is especially pertinent to the current study. The chosen protocol must be in line with both international standards and local feasibility because variations in examiner technique, testing posture, and device sensitivity can all affect results. The work of Krause et al. offers a framework for striking a balance between methodological rigor and practical applicability, which becomes crucial in the rural Gujarati context.

When considered collectively, the evidence highlights that normative data are context-dependent and not static, impacted by methodological variances, cultural or regional practices, and demographic factors like age and gender. By filling a significant gap in the literature—namely, the lack of normative cervical core muscle function data in rural Indian populations, especially in Gujarat—the current study advances this expanding field. Because of this regional focus, clinicians working in these communities are guaranteed access to reference values that accurately represent the distinct patterns of physical activity, workrelated demands, and lifestyle traits of the people they serve. In addition to supporting clinical judgment, the establishment of such data lays the groundwork for upcoming comparative studies that will expand our knowledge of cervical muscle function worldwide.

By comparing different cervical muscle strength testing techniques, Krause et al. (2018) further supported this claim, finding that male participants consistently displayed higher absolute strength values. However, the differences were frequently lessened when normalized to body size, indicating that anthropometric factors are also important when interpreting performance based on gender.

The results of the current study support these findings, as normative data from rural Gujarat showed that men had greater cervical corestrength values than women. It is important to stress that these differences are physiological and anatomical variations rather than signs of impairment. Clinicians can better interpret assessment results by stratifying normative values by gender, avoiding the problems that arise from applying the same benchmarks to both sexes.

6. Conclusion

1) The reference range for strength of Cervical muscle is 2-10 mmhg.
2) Reference range varies according to age and gender.
3) As the age increases from 20 to 60 years group, strength is reducing showing inversally proposnal
4) Referene range of male shows higher mean value compare to female.

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