

# Phrenic Nerve Impingement and Effect of Superficial Neck Flexors Stretching in Improving Diaphragmatic Function among Patient with Chronic Neck Pain

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**ABSTRACT - Background:** The phrenic nerve is formed on the lateral border of scalenus anterior. It runs vertically downward on the anterior surface of the scalenus anterior. The muscle is oblique and nerve cross it obliquely from its lateral to medial border. In this part the nerve is related anteriorly sternocleidomastoid. The decline in the diaphragm function can occur due to phrenic nerve block but to the best of our search, there is dearth of literature pertaining to involvement of phrenic nerve in patient with chronic neck pain secondary to superficial neck flexors tightness. So, evaluation of these muscle for tightness may be considered which may affect the maximum inspiratory pressure (MIP).

**Objective:** To find the change in diaphragmatic function secondary to phrenic nerve impingement measured through maximum inspiratory pressure (MIP) following stretching of superficial neck flexors in patient with chronic neck pain

**Methods:** An experimental (pre-post design) study involving 40 subjects with mean ( $\pm$ SD) age  $22.4 \pm 2.8$  years was performed. Using purposive sampling 40 subjects (77.5% female and 22.5% male) were used to check phrenic nerve impingement by looking at the effect of superficial neck flexors stretching (sternocleidomastoid and anterior scalene) in improving diaphragmatic function in patient with chronic neck pain. The included subject's diaphragmatic function was measured through maximum inspiratory pressure using a device capsule sensing pressure gauge followed by stretching of superficial neck flexors on both sides. After two minutes of stretching diaphragmatic function was again measured.

**Results:** There was increase in diaphragmatic function following stretching of superficial neck flexors by 13.2cm H<sub>2</sub>O which was found to be highly significant statistically with p value < 0.01

**Conclusion:** The result of present study concluded that superficial neck flexors stretching was effective in treating the impingement of phrenic nerve as measured through maximum inspiratory pressure in patients with chronic neck pain.

**Keywords:** phrenic nerve, impingement, chronic neck pain, superficial neck flexors tightness

## I. Introduction

Neck pain is one of the most costly musculoskeletal problem which has tremendous impact on the quality of life of the individual and society<sup>1</sup>. Majority of the individuals experience neck pain with an estimation of around 67% of the individuals suffer neck pain at some stage throughout life<sup>2-3</sup>. Chronic neck pain has received considerable clinical research attention.

Previous research on chronic neck pain patients has demonstrated reduced strength of deep cervical flexors and extensors, increased fatigability and increased activity of superficial neck flexors (SCM and anterior scalene muscle), reduced neck range of motion, increased forward head posture. All the above mentioned factors have higher susceptibility towards Respiratory dysfunction<sup>1</sup>.

With the rise in sedentary behaviour and the use of computers in the office<sup>3</sup>, neck pain has become a common health concern among general population and mainly in computer users<sup>2</sup>. The EMG signals shows increase fatiquibility of superficial neck flexors and decreased endurance in chronic neck pain patients. In the group of people with neck pain, pain may increase motor unit synchronisation for the Sternocleidomastoid and Anterior scalene muscles, which would cause myoelectric fatigue symptoms to appear earlier<sup>4</sup>. This increased fatiquibility and overactivity of Sternocleidomastoid and anterior scalene muscle, results in muscle shortening, trigger formation, as well as enlargement of these muscle group due to “muscle imbalance” and “pain”.

Several studies have suggested a strong co- relation between abnormal breathing pattern and musculoskeletal pain patterns, respiratory dysfunctions due to chronic neck pain, increased forward head posture and decreased respiratory muscle strength in neck pain patients <sup>1</sup> and increase in the thickness of Sternocleidomastoid muscle in patients with neck pain during cranio- cervical flexion exercise (CCFE) due to inability of deep cervical flexors to stabilise the neck as a result superficial muscle including SCM and anterior scalene were activated during CCFE<sup>5</sup>.

Diaphragmatic breathing requires synchronized motion of upper ribcage, lower ribcage and abdomen. It require adequate use and functionality of diaphragm muscle which is innervated by phrenic nerve arising chiefly from C4 but also receive contribution from C3 and C5. The nerve is formed on the lateral border of scalenus anterior. It runs vertically downward on the anterior surface of the scalenus anterior. The muscle is oblique and nerve cross it obliquely from its lateral to medial border. In this part the nerve is related anteriorly to prevertebral fascia, internal juglar vein and SCM<sup>6</sup>. Anatomically, if superficial neck flexors gets tightened, may results in phrenic nerve impingement. Thus, affecting diaphragmatic function.

There are various method used to measure diaphragmatic strength, some are volitional while some are non-volitional tests. Measurement of twitch oesophageal, gastric and trans diaphragmatic pressure during bilateral electrical and magnetic phrenic nerve stimulation are the non- volitional tests used to assess diaphragmatic strength. Volitional test include pulmonary function tests, Polysomnography, arterial blood gases, sniff pressure, sniff trans diaphragmatic pressure, mouth pressures (maximal inspiratory and expiratory mouth pressures). All these methods are difficult, painful and expensive to perform except mouth pressures<sup>7</sup>.

Meaurement of maximum inspiratory pressure is an easy, brief and non- invasive method for determining inspiratory muscle strength<sup>8</sup> basically of diaphragm muscle<sup>9</sup> among healthy subjects and in patients with pulmonary or neuromuscular disorders. Maximum inspiratory pressure is the greatest sub-atmospheric pressure which is generated during inspiration towards and occluded airway. It reflects the force- generating ability of the inspiratory muscles during a brief- static contraction, therefore reflecting the strength of the inspiratory muscle. The capsule- sensing pressure gauge (CSPG- V) is a classically established device available to measure mouth pressure, for the assessment of inspiratory muscle strength. It is easy to use, non-invasive, inexpensive and lightweight device to measure inspiratory strength, therefore it is widely used above all technique<sup>8</sup>.

Respiration is influenced directly or indirectly by the increased activation and fatigability of Sternocleidomastoid and anterior scalene muscle among neck pain patients as a result of changes within the functional length and recruitment, leads to change in rib- cage mechanics<sup>1</sup>. It is also observed that when the muscle are in shortened position and if the nerve crosses over these shortened muscle, there is increased chances of compression on the nerve due to tension or direct pressure on the nerve, thereby affecting the mobility and function of the nerve<sup>10</sup>. Impingement of phrenic nerve due to tightness of anterior scalene and Sternocleidomastoid may influence the function of diaphragm muscle affecting maximal inspiratory pressure. To the best of our search, there is dearth of literature pertaining to involvement of phrenic nerve in patient with chronic neck pain secondary to anterior scalene and SCM tightness. So, evaluation of these muscle for tightness may be considered which may affect the inspiratory function.

The objective of the present study was to find the change in diaphragmatic function secondary to phrenic nerve impingement measured through maximum inspiratory pressure following stretching of superficial neck flexors in patient with chronic neck pain.

## II. Methods

The present study was experimental (pre-post design) study. A sample of 40 subjects was included using purposive sampling technique. The sample size was calculated by estimation of mean formula. The mean ( $\pm$  SD) age was  $22.4 \pm 2.8$  years. The subjects included in the analysis were those with chronic neck pain (>3 months), subjects with tightness of sternocleidomastoid and anterior scalene muscle in age group between 18-35 years of either gender. Excluded from analysis



were subjects with acute neck pain, individuals with neck surgery, any diagnosed medical and surgical condition causing decreased range of motion of neck, individuals with respiratory disorders affecting diaphragm function.

**A. Procedure**

The assessment of anterior scalene and sternocleidomastoid tightness was done through range of motion (lateral flexion and extension) using universal goniometer<sup>11</sup> and scalene cramp test in which subjects were asked to rotate the head fully towards the pain side and by flexing the head and neck actively pull the chin down into the hollow just above the clavicle, both the anterior and middle scalene muscles contract strongly in the shortened position during the terminal part of this movement, indicating tightness of scalene muscle<sup>12</sup>. After the assessment, measurement of diaphragmatic function (maximum inspiratory pressure) was done using device capsule sensing pressure gauge. During MIP measurement, the participant were made to sit on a chair in a relaxed comfortable position and was asked to hold the gauge with both hands and was instructed to close his or her lips firmly around the flanged mouthpiece. The participant were asked to close his or her nose with their hand to avoid leaking of air through nose and were instructed to exhale maximally (to residual volume) and then to inhale as much as possible through the mouth piece while reading was recorded by the investigator. Each subjects performed three inspiratory efforts, and each effort was sustained for at least 1second. Verbal encouragement was given throughout the test. An interval of approximately 1 min was allowed to elapse between each effort<sup>8</sup>, following which stretching of superficial neck flexors (anterior scalene and sternocleidomastoid) <sup>13, 14</sup> was done. The hold time for stretching was 30 sec and repeated for 3 times<sup>15</sup>. Within 2 minutes of the stretching maximum inspiratory pressure was again measured using capsule sensing pressure. Data was recorded and analysed.

**III. Statistical Analysis**

The data was analysed using SPSS version 16 software. Descriptive statistics was used to summarize the demographic variables. Paired t-test was used to check the mean change in Maximum Inspiratory Pressure (MIP) among participant with chronic neck pain. P value< 0.05 was considered significant.

**IV. Results**

Table 1 depicts the mean age, mean cervical extension, and mean lateral flexion (right and left) side of the participants and Table 2 summarizes the mean change in diaphragmatic function following stretching of superficial neck flexors.

Graph 1 summarizes the gender distribution in our study whereas Graph 2 summarizes the diaphragmatic function before and after the stretching.

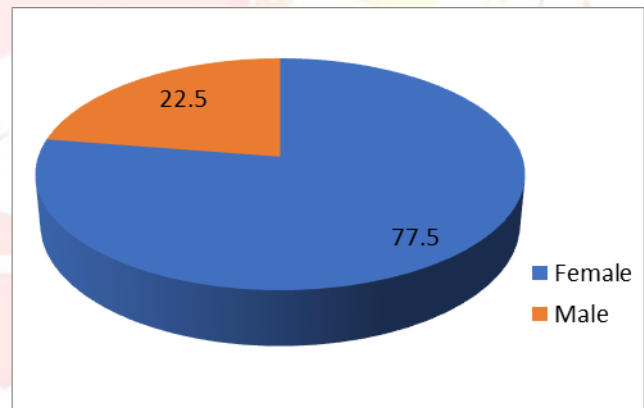
*Table 1: Showing Demographic characteristics of the participants*

Variables	Mean± SD
Age (in years)	22.4 ± 2.8
VAS Score	5.6 ± 1.2
Cervical Extension (in degrees)	45.9 ± 10.6
Cervical Lateral flexion(R) (in degrees)	25.2 ± 5.5
Cervical Lateral flexion(L) (in degrees)	27.1 ± 5

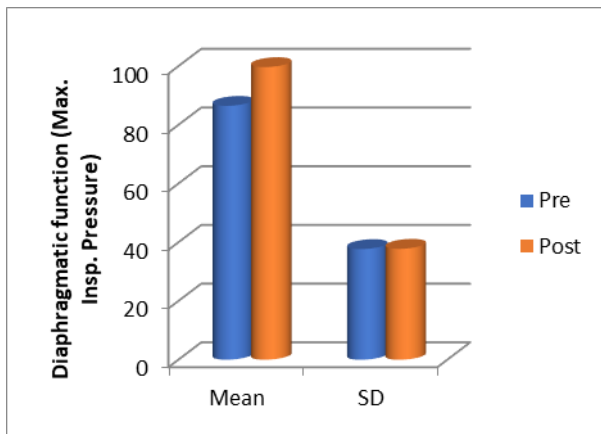
*Table 2 Showing Diaphragmatic Function of the participants following stretching of Superficial neck flexors:*

Diaphragmatic Function	Mean± SD	P value
Pre Stretching	86.5 ± 37.7	<0.01**
Post Stretching	99.7 ± 37.8	

\*\* Highly significant



*Graph 1: Showing gender distribution of the participants.*



Graph 2: Showing change in diaphragmatic function (measured through maximal inspiratory pressure) following stretching

## V. Discussion

Present study was conducted to see the alteration in diaphragmatic function due to phrenic nerve impingement which can occur due to tightness of superficial neck flexors. So, we looked at the change in diaphragmatic function measured through maximum inspiratory pressure following stretching of superficial neck flexors in patient with chronic neck pain.

Total 40 subjects participated in the study. Mean age of the participant in our study was 22.4 years. This depicts the occurrence of pain even in younger population. Majority of the population in our study were college going students where neck pain is related to static and faulty working posture<sup>16</sup> and computer use. Various epidemiological studies have been published relating neck pain with computer screen height. High screen height result in neck being more erect, which causes hyperactivity of Sternocleidomastoid and neck extensors whereas low screen height increases neck flexion, hyperactivity of neck extensors and increased compressive loading of neck ligaments, joint capsules and other structures of the cervical spine, thus possibly increasing musculoskeletal strain resulting in occurrence of neck pain<sup>17</sup>.

Another study conducted by P. Nejati et al.<sup>18</sup> reported correlation between forward head posture and neck pain among office workers. This study reported improper posture attained while working on computer may result in neck pain.

In the present study neck pain was dominant in female population (77.5%). This is supported by various authors reporting higher prevalence of neck pain among females.<sup>19,20</sup>

The reason for neck pain could be due to relatively weaker neck muscles which can cause early muscular fatigue resulting in higher incidence of chronic neck pain<sup>21</sup>.

The mean VAS score of the participant in our study was  $5.6 \pm 1.2$  which shows that pain was not the factor for reduced range of motion. So, muscle tightness can be attributed to decreased range of motion.

The mean cervical extension range in our study population was  $45.9 \pm 10.6$  depicting significant reduction in extension range than normal value<sup>[22]</sup>. A study by L-Y Guo et al.<sup>[24]</sup> related poor posture mainly forward head posture with reduced range of extension. The primary problem in forward head posture are shortening and hyper activation of the sternocleidomastoid muscle <sup>[25,26]</sup>. Thus, sternocleidomastoid tightness may result in forward head posture thereby reducing extension range in neck pain group<sup>[27]</sup>.

In the present study the mean cervical lateral flexion on right side was 21.2 degree and on the left side it was 27.1 degree showing marked reduction in length of anterior scalene bilaterally.

The mean diaphragmatic function of the participants in our study was  $86.5 \pm 37.7$  cm H<sub>2</sub>O before stretching. As observed from the neck ROM and scalene cramp test, there was tightness of SCM and anterior scalene. It is observed from literature <sup>10</sup> that when the muscle are in shortened position and if the nerve crosses over these shortened muscle, there is increased chances of compression on the nerve due to tension or direct pressure on the nerve thereby affecting the function of muscle supplied by nerve. In our study, when stretching was given to these shortened muscle, diaphragmatic function was increased by 13.2 cm H<sub>2</sub>O (mean) as measured through maximum inspiratory pressure. This change in diaphragmatic function was found highly statistically significant i.e., p value  $< 0.01$ . The improvement in diaphragmatic function could be related to enhancement of phrenic nerve function due to stretching of SCM and anterior scalene showing positive effect of stretching on nerve function thereby improving the function of diaphragm. This findings confirms the impingement of phrenic nerve thereby decreasing function of diaphragm as measured through maximum inspiratory pressure. This can be supported by study on stretching of scalene and pectoral muscle improving nerve function in thoracic outlet syndrome<sup>[28]</sup>, tight pronator teres may compress the median nerve in the forearm, so stretching of pronator teres muscle also improve median nerve function<sup>10</sup>, stretching of wrist and finger flexors is based on principle of



mobilisation of median nerve and decompression of median nerve in the carpal tunnel syndrome[29], soft tissue mobilization of scalene, pectoralis minor, bicipital aponeurosis, pronator teres, transverse carpal ligament and palmar aponeurosis along with nerve slider neurodynamic decreased pain intensity in carpal tunnel syndrome[30].

## VI. Limitations

1. Objective assessment of muscle length was not done.
2. Indirect measure for diaphragmatic function was done. Direct measurement of diaphragmatic function can yield more accurate result.
3. Further studies should focus on any other adjuncts can be given along with stretching, direct measurement of diaphragmatic function to yield more accurate result, more accurate assessment for muscle tightness of SCM and anterior scalene.

## VII. Clinical implications

The clinical implication of the present study include impingement of phrenic nerve due to superficial neck flexors tightness can affect the diaphragmatic function indirectly. Thus, musculoskeletal assessment for tightness of these muscle should also be considered to improve the inspiratory capacity in patient with respiratory problem. Also patient with respiratory problem, uses their accessory muscle during inspiration, which may result in fatigue and tightness of these muscle further impinging phrenic nerve between SCM and anterior scalene and affecting diaphragmatic function. So, stretching of these muscle should be given to improve diaphragmatic function and also to reduce the risk of phrenic nerve impingement.

## VIII. Conclusion

The present study concluded that superficial neck flexors stretching was effective in correcting the impingement of phrenic nerve as measured through maximum inspiratory pressure in patients with chronic neck pain.

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