INDIAN JOURNAL OF SCIENCE AND TECHNOLOGY

RESEARCH ARTICLE

Effect of Respiratory Training on Pulmonary Functions and Cervical ROM in Non-Specific Chronic Neck Pain

M Manasa Mercy[1], Jincy Samuel[1]*

1 Krupanidhi College of Physiotherapy, Bengaluru, 560035, Karnataka, India

OPEN ACCESS

Received: 19-09-2023

Accepted: 25-08-2024

Published: 07-12-2024

Citation: Mercy MM, Samuel J (2024) Effect of Respiratory Training on Pulmonary Functions and Cervical ROM in Non-Specific Chronic Neck Pain. Indian Journal of Science and Technology 17(45): 4704-4710. https://doi.org/10.17485/IJST/v17i45.2381

* **Corresponding author**.

physio.kric@krupanidhi.edu.in

Funding: None

Competing Interests: None

Published By Indian Society for Education and Environment (iSee)

ISSN
Print: 0974-6846
Electronic: 0974-5645

Abstract

Objectives: Non-Specific Chronic Neck (NS-CNP) is a multifactorial condition with excessive activity of accessory muscles of respiration in the neck. Studies have portrayed significant relationships between chronic neck pain and respiratory parameters. The study intends to find the impact of respiratory training on lung function and cervical ROM in NS CNP. **Methods:** The study recruited 64 subjects with pain who were advised to undergo conventional electrotherapy for a week. Pre-intervention measurements were taken, and subjects were divided into 2 groups. Group A received respiratory training and conventional therapy, while Group B received conventional therapy. Post-test measurements were recorded and statistically analyzed. **Findings:** The post-values of all the outcome measures were significant with an obtained p-value of 0.00, which is <0.05 in both Group A and Group B. Comparing all the outcome measures between the groups showed a significant difference in Cervical flexion along with FVC, SVC, and MVV with the obtained p values of <0.05 which is below the threshold chosen for the statistical analysis. **Novelty:** The novelty of this study is to implement respiratory training along with conventional neck exercises in the management of NS-CNP. **Conclusion:** This study concludes that respiratory training and conventional neck exercises significantly improved neck mobility and pulmonary function.

Keywords: Cervical pain; Respiratory training; Neck range of motion; Pulmonary functions; Forced vital capacity

1 Introduction

Chronic Neck Pain (CNP) is a frequent musculoskeletal ailment associated with considerable impairment, with a prevalence of 19.3% among the Indian population [1]. It is a common condition accompanied by added dysfunction in other body areas. It lasts for a longer time and substantially influences one's health and quality of life [2]. In addition, NS-CNP is a condition that is frequently reported and is caused by non-specific causes, in which pain persists for more than 3 months. It is mainly localized pain in the lateral and posterior parts of the neck [3].

The most frequent adaptive posture associated with NS-CNP is the forward head position (FHP). Individuals with FHP frequently experience significant neck flexor weakness, usually compensated by overuse of the neck accessory muscles of respiration[2]. Due to excessive activity of the Sternocleidomastoid (SCM), Anterior scalene (AS), and Upper Trapezius (UT), there are many physiological changes occur which is associated with the respiratory system, thoracic cage, and cervical Range of motion (ROM)[1–3].The significant complaints seen with NS-CNP are discomfort and reduced neck mobility associated with respiratory dysfunction, respiratory muscle weakness, an abnormal breathing pattern, and reduced pulmonary functions[1,2,4]. In NS-CNP, the deep and superficial cervical muscle strength and endurance decrease, cervical mobility is reduced, and head posture changes[1].When there is reduced muscle strength in the deep and superficial muscles, there is also a change in head posture due to weakness, which leads to postural changes in the thoracic spine[4].

Studies have revealed a significant correlation between chronic neck pain and respiratory parameters such as respiratory muscle weakness, pulmonary volumes, especially MVV, SVC, and FVC, and breathing patterns[4]. Previous studies emphasized a correlation between respiratory dysfunction and NS-CNP. The dysfunction occurs in three significant aspects: respiratory muscle weakness, abnormal breathing patterns, and reduced cervical ROM[5].

Chronic neck pain causes neck mobilizers like the sternocleidomastoid, anterior scalene, and upper trapezius to overwork, causing increased load on neck stabilizers. This overload alters cervical and thoracic spine mechanics, affecting respiration and respiratory muscle function[6]. Because of this, an abnormal breathing pattern uses the upper thorax, the accessory muscles. Long-term usage of the accessory muscles will also alter the length-tension curves of the primary respiratory muscles, leading to less recruitment and reduced respiratory muscle strength[6,7].Neck muscle length and recruitment impact the cervical ROM, increasing the fatigability of SCM, AS, and UT. Abnormal overpull and underpull of the cervical region cause changes in primary respiratory muscles and rib cage mechanics, affecting upper thoracic breathing. In NS-CNP, the thoracic spine and rib cage are compromised, affecting respiratory patterns like SVC, FVC, and MVV[5,6].

A study done by Dareh-deh et al pointed out the significant correlation between CNP and Respiratory dysfunction and provided therapeutic neck conventional exercises along with respiratory training, to find the effect of combined therapy on chronic neck pain. Assessing the EMG muscle activity and respiratory pattern showed a significant improvement in pain and mobility of neck pain as well as improving respiratory muscle strength[2].Similar studies showed that the breathing re-education combined with endurance and strength training of deep neck flexors, and pulmonary function in CNP significantly improved in deep neck flexor strength and forced vital capacity[7]. A systematic review done by Tatsios et al suggests that manual therapy (MT) such as diaphragm mobilization and core stability exercises supplemented with re-education of diaphragmatic breathing improved pulmonary function in patients with CNP. However, there was a significant variation in interventional techniques, and the confidence in evidence ranged from low to very low[8].

To our knowledge fewer studies are done on improving pulmonary parameters in NS-CNP and one study suggests the need for advanced respiratory assessment and other studies highlight the potential for exploring additional parameters beyond FVC and FEV1 in pulmonary function testing[7,8]. This indicates the need for further research on respiratory training programs and respiratory exercises in rehabilitation for non-specific CNP. This study's novelty is implementing respiratory training in the management of NS-CNP.

This research intended to evaluate the outcomes of respiratory training on non-specific CNPs' cervical ROM and lung functioning. The objectives were to evaluate the impact of respiratory training on pulmonary functions in non-specific CNP. They were to evaluate the impact of the respiratory training on cervical ROM in non-specific CNP.

2 Methodology

2.1 Participants

This was a Quasi-experimental study done from August 2022 to June 2023 after obtaining ethical clearance from the Krupanidhi College of Physiotherapy Ethical Committee with reference number EC-MPT/2022/PHY/005. The study included 64 NS- CNP subjects. These subjects were segregated into experimental and control groups from OPD, Krupanidhi College of Physiotherapy, and other multi-specialty clinics. The inclusion criteria were individuals with CNP suffering for past three months[7], VAS of 4 –7, moderate intensity[2], age group 35 to 45 years[9], both genders[1,7], NDI scores of > 22 % of disability using the Neck disability index questionnaire, PFT baseline values as FVC - < 80% of the predicted value, MVV - <70% of the predicted value SVC - <80% of predicted value[10].

Subjects with a history of neck and thoracic surgeries[2], recent cardiorespiratory conditions affecting pulmonary function, systematic or metabolic disease (e.g., rheumatoid arthritis or cancer), postural deformities (e.g., pectus excavatum, scoliosis)[10], subjects on pain medications and history of COVID-19 were not included in this study. Subjects underwent one week of conventional electrotherapy treatment to reduce pain. Interferential therapy and ultrasound were given with the mentioned dosage: interferential therapy (15 minutes), frequency 100 Hz, intensity depending upon the patient, and ultrasound therapy (8 minutes), continuous mode, 1.8 watt/cm^2 intensity. Using the simple random sampling method, the subjects were segregated into two groups (Group A Experimental Group, N = 32, and Group B Control Group, N = 32). Group A received the intervention, the IMT device, and balloon exercise in addition to traditional neck exercises for 30 – 45 minutes three days per week for four weeks. Group B received conventional neck exercises for the same duration. Pre- and post-cervical ROM and PFT were assessed and recorded.

2.2 Outcome measures

2.2.1 Pulmonary function test:

FVC, MVV, and SVC were assessed using spirometry (Spiroexcel PC-based Pulmonary function test device) [9,10].

2.2.2 Cervical Range of Motion (CROM) :

Active CROM, primarily left lateral and right lateral rotation, flexion, and extension, was measured using an Inclinometer [11,12].

2.3 Intervention

Before the intervention, the outcome measured were assessed for the pre-test data.

After the collection of pre-data, subjects in Group A were given an Inspiratory muscle training device (Phillips IMT device) [13–16] and balloon exercise [17–19] along with conventional neck exercise. Group B was given only conventional neck exercises. The Experimental Group A received an Inspiratory Muscle training device for 15 minutes, balloon exercise – 12 repetitions, [17,18] and neck stretching and strengthening exercises for 30 – 45 minutes. All exercises were done at a frequency of three days per week and a duration of four weeks. Group B received neck stretching and strengthening exercises for 30 – 45 minutes three days/ week for four weeks.

Neck stretching and strengthening exercises include the static levator scapulae stretch, unilateral self-stretch exercise of Pectoralis minor, static sternocleidomastoid stretch, and trapezius stretches [2].Neck isometric exercise (trapezius, scalene), prone horizontal abduction with external rotation, chin tuck (Longus colli, Longus capitis) [2] 30 to 45 minutes per session, three sessions per week alternative days, for four weeks. For stretching 5 to 10 repetitions, 30 seconds hold for two sets. For strengthening exercise, 5 to 10 repetitions for two sets. Rest interval for stretching exercises will be 30 seconds, and for resisted exercises, 45 seconds [2]. After four weeks of intervention, the post-outcome measure tests were taken. Among Group A, three subjects and Group B, two subjects were excluded from the study due to post-measurement errors. Group A 29 subjects and Group B 30 subjects' pre- and post-data were recorded, and statistical analysis was done.

2.4 Statistical analysis

The data was examined using SPSS (version 29.0). The mean and standard deviation for the demographic variables and outcome indicators were calculated using descriptive statistics. To identify the significant variations within the group, a paired t-test was performed. To find the significant difference between the groups, an independent t-test was used. The significance level was set at p 0.05.

3 Results and Discussion

Table 1 shows the evaluation of the collected data using the Mann-Whitney U test to check the groups' differences. U value is 365.500, and the P Value is 0.28, > 0.005. This indicates that the age distribution between the groups was homogeneous.

Table 1. Mann-Whitney test for age

Group	Mean	Sd	U Value	Significance
Group a (Exp group)	37.72	3.23	365.500	0.28
Group b(Control group)	38.23	3.11		

SD – Standard deviation, EXP – Experimental

Table 2 shows the baseline values of age and BMI among the subjects taken for the study. In Group A, 29 subjects and in Group B, 30 subjects were considered based on the inclusion criteria of age group 35 – 45 years. The mean age of the subjects in Group A was 37.72 $\pm$ 3.23, and Group B was 38.23 $\pm$ 3.11. The BMI was calculated for the subjects who participated in the study based on height and weight. The subjects' mean BMI (kg/m2) in Group A was 22.26 $\pm$ 2.96, and in Group B was 22.40 $\pm$

1.75.

Table 2. Descriptive statistics of baseline variables

Variables	Group A		Group B	
	Mean	Sd	Mean	Sd
Age (in years)	37.72	3.23	38.23	3.11
BMI (kg/m^2)	22.26	2.96	22.40	1.75

Table 3. Comparison within group-A for cervical rom and pulmonary functions

Group A (Experimental)	Mean		Mean Diff	Sd		Sd Diff	T Val	P Val	Inference
	Pre	Post		Pre	Post				
Cervical flexion	48.55	53.53	- 5.27	3.16	2.10	2.32	12.20	0.000	Significant
Cervical extension	43.72	48.90	- 5.17	3.18	2.36	1.71	16.26	0.000	Significant
Left lateral rotation	46.28	47.79	- 1.51	5.01	4.70	0.78	10.41	0.000	Significant
Right lateral rotation	46.66	48.90	- 2.24	3.85	3.57	0.83	14.53	0.000	Significant
FVC %	65.95	77.00	- 11.05	6.90	7.59	3.98	-14.94	0.000	Significant
SVC %	68.74	80.67	- 11.93	5.12	4.93	5.04	-12.74	0.000	Significant
MVV %	32.36	47.88	- 15.52	17.82	21.19	10.3	-8.11	0.000	Significant

The paired t-test within the group for Group A, as shown in Table 3, interprets the pre-value for Cervical Flexion as 48.55 ± 3.16 and the post-value as 53.53 ± 2.10. The pre-value for cervical extension was 43.72 ± 3.18, and the post-value was 48.90 ± 2.36. For Cervical Left lateral rotation, the pre-value was 46.28 ± 5.01, and the post-value was 47.79 ± 4.70. For Cervical proper lateral rotation, the pre-value was 46.66 ± 3.85, and the post-value was 48.90 ± 3.57. For FVC, the pre value was 65.95 ± 6.90, and the post value was 77.00 ± 7.59. For SVC, the pre value was 68.74 ± 5.12, and the post-value was 80.67 ± 4.93. For MVV, the pre-value was 32.36 ± 17.82, and the post-value was 47.88 ± 21.19. The p-values for all outcome measurements were 0.000 (0.05), indicating a significant difference for Group A. Therefore, this suggests that four weeks of respiratory training and conventional therapy were statistically significant in improving the cervical ROM and pulmonary functions in NS-CNP. This confirms the alternate hypothesis and rejects the null hypothesis.

Table 4. Comparison within group B for cervical rom and pulmonary functions

Group B (Contl)	Mean		Mean diff	Sd		Sd Diff	T Val	P Val	Inference
	Pre	Post		Pre	Post				
Cervical flexion	48.53	52.13	- 3.60	3.31	2.71	1.45	13.57	0.000	Significant
Cervical extension	45.20	48.27	- 3.06	3.58	2.81	1.79	9.33	0.000	Significant
Left lateral rotation	45.97	47.80	- 1.83	3.44	3.14	0.10	16.95	0.000	Significant
Right lateral rot	46.87	48.63	- 1.76	3.14	4.05	0.16	10.78	0.000	Significant
FVC %	66.95	73.38	- 6.42	5.41	5.40	2.28	-15.40	0.000	Significant
SVC %	66.96	76.30	- 9.34	7.48	6.56	4.22	- 12.11	0.000	Significant
MVV %	33.36	38.40	- 5.03	14.20	13.19	2.58	-10.67	0.000	Significant

The paired t-test within the group for Group B, as shown in Table 4, interprets the pre-value for Cervical Flexion as 48.53±3.31 and the post-value as 52.13±2.71. For cervical extension, the pre- and post-value was 45.20±3.58 and 48.27±2.81. For cervical left lateral rotation, the pre- and post-value was 45.97±3.44 and 47.80±3.14. For cervical proper lateral rotation, the pre- and post-value was 46.87±3.14 and 48.63±4.05. For FVC, the pre- and post-value was 66.95±5.41 and 73.38±5.40. For SVC, the pre- and post-value was 66.96±7.48 and 76.30±6.56. For MVV, the pre- and post-value was 33.36±14.20 and 38.40±13.19. The p-values for all outcome measurements were 0.000 (0.05), indicating a significant difference for Group B. Therefore, this suggests that four weeks of conventional therapy was statistically significant in improving the cervical ROM and pulmonary functions in non-specific chronic neck pain. This confirms the alternate hypothesis and rejects the null hypothesis.

Table 5. Comparison between both the groups for cervical rom and pulmonary functions

Variable	Group	Mean	Sd	Mean diff	T value	P value	Inference
Cervical flexion pre	Exp group Control group	48.55 48.53	3.16 3.31	0.01	0.02	0.983	Not significant
Cervical flexion post	Exp group Control group	53.83 52.13	2.10 2.71	1.69	2.67	0.010	Significant
Cervical extension pre	Exp group Control group	43.72 45.20	3.18 3.58	- 1.47	-1.67	0.100	Not significant
Cervical extension post	Exp group Control group	48.90 48.27	2.36 2.81	0.63	0.929	0.356	Not significant
Cervical left lateral rot pre	Exp group Control group	46.28 45.97	5.01 3.44	0.30	0.277	0.783	Not significant
Cervical left lateral rot post	Exp group Control group	47.79 47.80	4.70 3.14	- 0.007	-0.007	0.995	Not significant
Cervical proper lateral rot pre	Exp group Control group	46.66 46.87	3.85 4.05	- 0.21	-0.205	0.838	Not significant
Cervical right lateral rot post	Exp group Control group	48.90 48.63	3.57 3.69	0.263	0.278	0.782	Not significant
FVC % pre	Exp group Control group	65.95 66.95	6.90 5.41	-1.0049	-0.62	0.536	Not significant
FVC % post	Exp group Control group	77.00 73.38	7.59 5.40	3.62	2.11	0.038	Significant
SVC % pre	Exp group Control group	68.74 66.96	5.12 7.48	1.78	1.063	0.290	Not significant
S VC % post	Exp group Control group	80.67 76.30	4.93 6.56	4.36	2.88	0.005	Significant
MVV % pre	Exp group Control group	32.36 33.36	17.82 14.20	-1.004	-0.23	0.811	Not significant
MVV % post	Exp group Control group	47.88 38.40	21.19 13.19	9.48	2.05	0.043	Significant

Only a few outcome measures were statistically significant compared to the other variables using the independent t-test, as indicated in Table 5 of the results. For cervical flexion, the mean post value for Group A was 53.83±2.10, and for Group B was 52.13±2.17; the obtained p-value was 0.010 (<0.05). For FVC, the mean post value for Group A was 77.00±7.59, and for Group B was 73.38±5.40, the obtained p-value was 0.038(<0.05). For SVC, the mean post value for Group A was 80.67±4.93; for Group B, 76.30±6.56; the obtained p-value was 0.005(<0.05). For MVV, the mean post value for Group A was 47.88±21.19, and for Group B was 38.40±13.19, and the obtained p-value was 0.043(<0.05). Therefore, this suggests that four weeks of respiratory training and conventional therapy were statistically significant in improving cervical flexion and pulmonary functions in NS-CNP, confirming the alternate hypothesis and rejecting the null hypothesis.

In the current study, though a significant variance was seen within the group to improve the cervical ROM, the results were not significant between the groups as seen above in Table 5, suggesting that adding respiratory training to the protocol for a 4-week program may not contribute much towards cervical ROM. However, the intervention with a prolonged duration can be further explored.

Giving respiratory training (IMT and balloon exercise) along with conventional neck exercises helps to improve inspiratory and expiratory muscle performance, relax the neck mobilizers, and significantly improve the strength of the neck muscles. Adding respiratory exercises to conventional neck exercises reduces the contribution of the upper thoracic and neck muscles towards respiration as the primary respiratory muscle performance improves [20]. The current findings showed an improvement in the cervical ROM within both groups suggesting that with the reduction in pain and an improved cervical ROM due to the conventional exercises and by adding respiratory training to it which improves the respiratory muscle functioning, the overall neck posture rib cage mechanics and the breathing pattern improves. The study findings however didn't find a significant difference in the cervical ROM between the groups possibly because both the groups were given conventional exercises which improve cervical ROM. The addition of respiratory training may not directly influence the cervical ROM. With a reduction in pain and relaxed neck musculature, an improvement in respiratory muscle strength and the correction of breathing patterns could be a reason for the improvements in pulmonary function [20,21].

The present study findings agree with a few other previous studies. A study distributed CNP subjects into three groups: combined respiratory and neck exercises, respiratory exercises, and neck exercises. EMG assessment showed significant improvement in neck muscles, decreased SCM, AS, and UT activity, and corrected FHP. The combined therapy did not show any change in these muscles but increased the diaphragm activity [2]. Chand et al in their study also concluded that while designing rehabilitation strategies for neck pain, it should include breathing exercises to improve the functioning of the respiratory system and reduce pain [22].

Shireen Anwar et al. did a randomized control study on CNP subjects comparing breathing re-education and conventional therapy at four weeks and eight weeks follow-up. Results revealed that cervical flexion, extension, and pulmonary indices had significantly improved. Compared to the current study, only the cervical flexion range was improved between the groups [23] . A systematic review and meta-analysis study done by Tatsios et al on the effectiveness of spinal, diaphragmatic, and specific stabilization exercise manual therapy and respiratory-related interventions in patients with NS-CNP. This study in correlation with the current study concluded that NS-CNP patients will show a significant improvement in pain and strength with diaphragmatic breathing and respiratory exercises [8].

This current study was one of the few to determine the effectiveness of adding a respiratory training device along with regular neck exercises for treating chronic neck pain. The results support additional respiratory training to enhance pulmonary function in CNP patients.

For the study's limitations, other outcome measures could be assessed to check the physiological improvement in the primary and secondary respiratory muscles, like chest expansion or electromyography to understand the respiratory muscle activity during the training in NS-CNP.

4 Conclusion

Respiratory parameters are affected in CNP due to the involvement of the accessory muscles of respiration in the cervical region and the poor posture acquired due to long-term NS-CNP. Fewer studies are done on improving pulmonary parameters in NS-CNP and these studies suggest the need for advanced respiratory assessment and to focus on additional parameters beyond FVC and FEV1 in pulmonary function testing. This indicates the need for further research on respiratory training programs and respiratory exercises in rehabilitation for non-specific CNP. Hence the study's novelty arises to implement respiratory training as a part of the management of NS-CNP.

The results of the current study concluded that respiratory training along with neck conventional exercises did have a significant effect on mobility and respiratory functions in subjects with CNP. Therefore, adding respiratory training to the neck rehabilitation protocol is essential to improve pulmonary function and mobility in NS-CNP subjects. The recommendations would be to incorporate a few advanced parameters to check the particular muscle activity during the respiratory exercise. Also, a long duration of intervention can be done to check the long-term effect along with follow-up.

References

1) Nair SP, Panchabhai CS, Panhale V. Chronic neck pain and respiratory dysfunction: a review paper. *Bulletin of Faculty of Physical Therapy*. 2022;27. Available from: https://doi.org/10.1186/s43161-022-00078-8.
2) Dareh-Deh HR, Hadadnezhad M, Letafatkar A, Peolsson A. Therapeutic routine with respiratory exercises improves posture, muscle activity, and respiratory pattern of patients with neck pain: a randomized controlled trial. *Scientific Reports*. 2022;12(1):4149–4149. Available from: https://doi.org/10.1186/s43161-022-00078-8.
3) Bernal-Utrera C, Gonzalez-Gerez JJ, Anarte-Lazo E, Rodriguez-Blanco C. Manual therapy versus therapeutic exercise in non-specific chronic neck pain: a randomized controlled trial. *Trials*. 2020;21(1). Available from: https://doi.org/10.1186/s13063-020-04610-w.
4) Cheon J, Hong. Differences of Spinal Curvature, Thoracic Mobility, and Respiratory Strength Between Chronic Neck Pain Patients and People Without Cervical Pain. *Annals of Rehabilitation Medicine*. 2020;44(1). Available from: https://doi.org/10.5535/arm.2020.44.1.58.
5) Awadallah MF, Sobh E, Shendy MA, Al-Shenqiti AM, Al-Jeraisi, Eweda TM, et al. Impaired pulmonary function in patients with chronic neck pain. *J Med Sci*. 2021;41:123–131. Available from: https://www.jmedscindmc.com/text.asp?2021/41/3/123/305054.
6) López-De-Uralde-Villanueva I, Corral D, Salvador-Sánchez T, Angulo-Díaz-Parreño R, López-Marcos S, Plaza-Manzano JJ, et al. Respiratory dysfunction in patients with chronic neck pain: systematic review and meta-analysis. . *Disability Rehabilitation*. 2023;45:2422–2433. Available from: https://doi.org/10.1080/09638288.2022.2096126.
7) Anwar S, Arsalan SA, Zafar H, Ahmed A, Gillani SA, Hanif A. Effects of breathing re-education on endurance, the strength of deep neck flexors and pulmonary function in patients with chronic neck pain: A randomized controlled trial. *South African Journal of Physiotherapy*. 2022;78(1). Available from: https://doi.org/10.4102/sap.v78i1.1611.
8) Tatsios PI, Grammatopoulou E, Dimitriadis Z, Papandreou M, Paraskevopoulos E, Spanos S, et al. The Effectiveness of Spinal, Diaphragmatic, and Specific Stabilization Exercise Manual Therapy and Respiratory-Related Interventions in Patients with Chronic Nonspecific Neck Pain: Systematic Review and Meta-Analysis. . *Diagnostics (Basel)*. 2022;12. Available from: https://doi.org/10.3390/diagnostics12071598.
9) Park HJ, Rhee CK, Yoo KH, Park YB. Reliability of Portable Spirometry Performed in the Korea National Health and Nutrition Examination Survey Compared to Conventional Spirometry. *Tuberc Respir Dis (Seoul)*. 2021;84(4):274–281. Available from: https://doi.org/10.4046/trd.2021.0016.
10) Zhang H, Li L, Jiao D, Yang Y, Pan C, Ye L, et al. An Interrater Reliability Study of Pulmonary Function Assessment with a Portable Spirometer. *Respir Care*. 2020;65(5). Available from: https://doi.org/10.4187/respcare.07116.

11) Ponce MC, Sankari A, Sharma S. Pulmonary Function Tests. *StatPearls Treasure Island (FL): StatPearls Publishing*. 2023. Available from: https://www.ncbi.nlm.nih.gov/books/NBK482339.
12) Ghorbani F, Kamyab M, Azadinia F, Ahmadi A. The Reliability and Concurrent Validity of Digital Inclinometer, Smartphone Applications, and the Cervical Range of Motion Device for Measuring the Cervical Range of Motion. *Iranian Rehabilitation Journal*. 2020;18(4):405–418. Available from: http://irj.uswr.ac.ir/article-1-1061-en.html.
13) Sukari AA, Singh SA, Bohari MH, Idris Z, Ghani AR, Abdullah JM. Examining the range of motion of the cervical spine: Utilising different bedside instruments. . *The Malaysian journal of medical sciences: MJMS*. 2021;28. Available from: https://doi.org/10.21315/mjms2021.28.2.9.
14) Cirak YB, Yelvar Y, D G, Elbasi D, N. Effectiveness of 12-week inspiratory muscle training with manual therapy in patients with COPD: A randomized controlled study. *Clin Respir J*. 2022;16(4):317–328. Available from: https://doi.org/10.1111/crj.13486.
15) Kim S, Hun. Effects of a new respiratory muscle training device in community-dwelling elderly men: an open-label, randomized, non-inferiority trial. *BMC Geriatrics*. 2022;22(1). Available from: https://doi.org/10.1186/s12877-022-02828-8.
16) Mcnarry MA, Berg RM, Shelley J, Hudson J, Saynor ZL, Duckers J, et al. Inspiratory muscle training enhances recovery post-COVID-19: a randomized controlled trial. *European Respiratory Journal*. 2022;60(4). Available from: https:://doi.org/10.1183/13993003.03101-2021.
17) Ahmadnezhad L, Yalfani A, Borujeni BG. Inspiratory muscle training in low back pain rehabilitation: a randomized controlled trial. *Journal of sport rehabilitation*. 2020;29(8). Available from: http://doi.org/10.1123/jsr.2019-0231.
18) Kanniappan V, Manivannan V. Efficacy of balloon blowing exercise on peak expiratory flow rate in young adult smokers. *Journal of Lifestyle Medicine*. 2020;10(2). Available from: http://doi.org/10.15280/jlm.2020.10.2.116.
19) Mohan V, Paungmali A, Sitilertpisan P, Henry LJ, Omar FA, Azhar FZ. The effect of core stability training with ball and balloon exercise on respiratory variables in chronic non-specific low back pain: An experimental study. *Journal of bodywork and movement therapies*. 2020;24(4). Available from: http://doi.org/10.1016/j.jbmt.2020.07.007.
20) Shikha B, Thapa B, Zafar S. Effect of balloon blowing exercise vs modified cervical exercise along with Swiss ball exercise on the lung capacity of patient suffering from text neck syndrome due to improper posture. *International Journal of Health Sciences*. 2022;6(S4):7497–7507. Available from: https://doi.org/10.53730/ijhs.v6nS4.11707.
21) Joshi R, Poojary N. The Effect of Muscle Energy Technique and Posture Correction Exercises on Pain and Function in Patients with Non-specific Chronic Neck Pain Having Forward Head Posture-a Randomized Controlled Trail.". *International journal of therapeutic massage & bodywork*. 2022;15. Available from: https://doi.org/10.3822/ijtmb.v15i2.673.
22) Chand, Vaish H. Effect of diaphragmatic breathing, respiratory muscle stretch gymnastics and conventional physiotherapy on chest expansion, pulmonary function and pain in patients with mechanical neck pain: A single group pretest-posttest quasi-experimental pilot study. *Journal of Bodywork and Movement Therapies*. 2023;36:148–152. Available from: https://dx.doi.org/10.1016/j.jbmt.2023.07.004.
23) Anwar S, Arsalan A, Zafar H, Ahmad A, Hanif A. Effects of breathing reeducation on cervical and pulmonary outcomes in patients with non specific chronic neck pain: A double blind randomized controlled trial. *PLOS ONE*. 2022;17(8):e0273471–e0273471. Available from: https://dx.doi.org/10.1371/journal.pone.0273471.