Effects of breathing reeducation on cervical and pulmonary outcomes in patients with non specific chronic neck pain: A double blind randomized controlled trial

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Abstract

Objective

The purpose of this randomized controlled trial was to study effects of breathing reeducation in the treatment of patients with non specific chronic neck pain.

Methods

A total of sixty eight eligible patients with chronic neck pain were randomly allocated to breathing reeducation (BR) group (n = 34) and routine physical therapy (RPT) group (n = 34). Clinical outcomes were neck pain measured through visual analogue score, cervical active range of motion through CROM device, strength of neck muscles through hand held dynamometer and endurance of neck muscles measured through craniocervical flexion test. The neck disability was measured through neck disability index (NDI) and pulmonary outcomes such as forced vital capacity (FVC), forced expiratory volume in one second (FEV1), and FEV1/FVC ratio were measured through Spirolab 4. The outcomes were assessed at baseline and at 4 and at 8 weeks from baseline.

Results

There were significant improvements in the BR group compared with the RPT group (P = 0.002) for cervical flexion, extension (P = 0.029), endurance (P = 0.042), strength of neck flexors (P <0.001), neck extensors (P = 0.034). Likewise there was a significant change in NDI (P = 0.011), FEV1 (P = 0.045), FVC (P <0.001), and FEV1/FVC ratio (P <0.001) in the BR group compared with the RPT group. The cervical side flexion and rotation showed no significant difference in breathing reeducation group with p > 0.05.
Conclusion
Breathing reeducation combined with routine physical therapy is an effective treatment in patients with non specific chronic neck pain.

Trial registration
IRCT 20200226046623N1, https://www.irct.ir/trial/46240.

Introduction
Chronic neck pain is one of the leading causes of disability imposing personal and socioeconomical burden throughout the world [1]. The unique anatomy of cervical spine and various muscular attachments not only contribute to cervical movements but they also play a vital role in head and neck stability [2], mastication [3], kinesthetic sensation for good posture [4] and rib cage movements for the respiration [5]. Thus any dysfunction of the cervical spine can affect these important functions of human movement. The prime contributing factor in non specific chronic neck pain is myogenic, as consistent pain for weeks results in muscular imbalance and according to a study an association exists between chronic neck pain and altered activation pattern of cervical and thoracic muscles [6].

It is well documented that in certain postures of cervical spine, some cervical muscles, especially the sternocleidomastoids and scaleni assume the role of accessory inspiratory muscles, and participate in rib’s elevation and thoracic stability [7]. The over activity of these muscles and inhibition of deep cervical muscles leads to shallow breathing, less expansion of rib cage, hypocapnia, anxiety and more pain [8]. Previous studies have shown that cervical spine’s hypo mobility, decreased neuromuscular strength and endurance of neck muscles, decreased cervical proprioception, and altered psychological state may influence respiratory mechanism [9–11]. According to a recent review, maximal breathing capacity, arterial blood gas pressure, strength of respiratory muscles and chest mechanics are affected in patients with chronic neck pain [12]. The strong neuromuscular interactions, well knitted cervicothoracic anatomy and biomechanical interactions of the cervical and thoracic spine lead to disturbance in normal respiratory mechanism which might result in respiratory dysfunction in subjects with non specific chronic neck pain [13].

Since the chronic neck pain can impart a negative effect on respiratory function of patients with long lasting neck pain, so a holistic treatment approach has been suggested to treat non specific chronic neck pain and its associated disorders [14, 15]. The primary focus of chronic pain treatment program is pain management and general relaxation; and breathing techniques are important part of this program [16]. There is an evidence regarding altered breathing patterns in chronic neck pain, and breathing reeducation has an immediate positive effect on reduction of cervical muscle over activity and respiratory functions [13, 17]. According to a previous study the use of feedback respiratory exercises resulted in significant differences in terms of sternocleidomastoid activity and NDI between control and experimental groups [18].

Despite of plenty of literature regarding treatment of non specific chronic neck pain focusing on a multimodal treatment approach there is a lack of evidence regarding scientific testing and implementation of new treatment methods. The studies focusing on treatment of non specific chronic neck pain may have incorporated strengthening or stretching of neck muscles with postural reeducation but, no evidence was found regarding incorporation of breathing
reeducation in the long term treatment protocol. According to a previous study breathing retraining may improve pain, movement patterns and neck muscle activity in patients with chronic neck pain [17]. However, in the said study only immediate effects of 30 minute breathing retraining with three different methods were observed on pain, cervical ROM and neck muscle activity without any explanation that which method was more favorable. In another study long term effects of breathing reeducation were studied in patients with neck pain but only pain, cervical range of motion and chest expansion were evaluated and no pulmonary function was assessed [19].

There remains an immense need of well designed randomized clinical trials regarding role of breathing reeducation in non specific chronic neck pain, with cervical and pulmonary outcome measures to suggest this treatment as part of holistic treatment protocols. Thus, the aim of the present study was to explore the effects of breathing reeducation on chronic neck pain, cervical ROM, neck muscles endurance, strength and quality of life. Additionally pulmonary functions were evaluated based on the hypothesis that improving the breathing pattern will result in improved respiratory capacity which might correct the abnormal activation pattern of superficial neck muscles, improve their force exerting capacity and improve quality of life.

Methods
Study design
This was a parallel group double blind (patient and assessor blind) randomized controlled trial with 1:1 allocation ratio in two groups. The trial was prospectively registered in Iranian registry of clinical trials (IRCT 20200226046623N1). The trial was conducted according to the consolidated standards of reporting trial CONSORT guidelines [20]. After ethical approval from the University of Lahore IRB - UOL- FAHS /697/ 2020: 23 January 2020, the data were collected from the patients attending the Physiotherapy Department District Headquarter Hospital Faisalabad, Pakistan. Written informed consent was taken from each participant prior to the study.

Sample size calculation
The sample of 68 (34 in each group) was taken, the sample size was calculated using following formula at 80% power of study and 95% confidence level. Sample size calculation was derived from T. Duymaz study [21].

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n = \frac{\{b_1^2 + b_2^2\} \times (z_{1-\alpha/2} + z_{1-\beta})^2}{(\mu_2 - \mu_1)^2}\]

Here, n = 34 in each group, \(z_{1-\alpha/2}\) = Standardized Level of Significance = 95% = 1.96, \(z_{1-\beta}\) = Power of test = 80% = 1.28, \(\mu_1\) = Mean in control group = 3.32, \(\mu_2\) = Mean in physical therapy treatment group = 3.85, \(\delta_1^2\) = standard deviation in control group = 0.38, \(\delta_2^2\) = standard deviation in physical therapy treatment group = 0.55.

Inclusion and exclusion criteria
Sixty eight patients with non specific chronic neck pain were recruited from the Physiotherapy Department, District Headquarter Hospital Faisalabad, Pakistan during August 2020 to June 2021. A systematic strategy was opted for the recruitment of patients through advertisement with posters and social media. The Patients were screened for the following eligibility criteria (1) nonspecific neck pain (2) neck pain duration for more than 3 months (3) willingness to participate in the study and random allocation. The patients were excluded from the study due...
to the following reasons (1) upper cervical symptoms (dizziness) (2) post traumatic neck pain, pain due to disc lesion, spondylosis and neck pain of nerve root origin [22] (3) smoking (4) asthma [23] (5) depression [24] (6) clinically obese patients and patients with any spinal deformity such as scoliosis and kyphosis. These conditions were excluded due to possible influence on the outcome measures during assessment and intervention maneuvers.

Randomization and masking
Randomization was done through sealed envelope method and patients were randomly divided in two groups, breathing group and routine physical therapy group in 1:1 ratio, by an independent administrator. All participants, clinicians, and outcome measure assessors were blinded to the randomization process. In addition, the participants and outcome measure assessors and participants were also blinded to the type of intervention.

Intervention
In routine physical therapy group, 34 patients (20 males, 14 females), mean age 39.00 ± 4.90 years, received a treatment comprised of infrared radiation (IRR) and isometric exercises of the neck muscles. Patients were instructed to lie in prone position and IRR was applied for 10 minutes on cervical region, followed by isometric exercises for cervical muscles (flexors and extensors) in supine lying with 10 second hold and 20 repetitions. After that each patient was instructed to perform placebo breathing exercises for 15 minutes. It was unsupervised random shallow routine breathing. In breathing reeducation group there were 34 patients (20 males, 14 females), mean age 39.70 ± 5.55 years, which received both routine physical therapy treatment and supervised breathing exercises. The supervision was done by an experienced physical therapist with more than ten years of experience in musculoskeletal and cardiopulmonary physical therapy. The details of the intervention are given below:

The patients were instructed verbally to assume a semi-Fowler’s position (To keep the torso supported and abdominal wall relaxed) and perform diaphragmatic breathing. The instructions were given in a smooth monotonous voice to avoid any distress or anxiety to the patients. The Patients were instructed to place one hand below the anterior costal margin, on the rectus abdominis and the other hand on the belly/navel region, and inhale slowly and deeply through the nose, from functional residual capacity to total lung capacity with a three-second inspiratory hold. It was followed by an instruction to relax the shoulders, keep the upper chest quiet in order that the abdomen is raised a little. The Patients were then instructed to exhale slowly through the mouth up to five seconds. The breathing exercises were performed in 3 sets for 15 minutes, each set lasted for 3 minutes with a rest of 2 minutes between each set. In between the repetitions of the diaphragmatic breathing exercise, the patient was told to breathe normally [25].

To avoid dizziness patients were advised to refrain from breathing from the top of the chest–try to keep the chest still and just let air in by allowing the stomach to gently rise and fall. Breathe through the nose and allow three seconds as they breathe in and five seconds as they breathe out. The total treatment time for both groups was the same. Patients of both groups received the intervention five days a week for consecutive 8 weeks.

Outcome measures
All outcomes measures were assessed by an assessor blind to treatment allocation. Pain and cervical ROM were assessed by visual analogue scale (VAS) [26] and CROM (basic) device by Performance Attainment Associates(TM)(USA) respectively. Functional disability was measured through neck disability index NDI (Urdu Version) [27]. Cervical muscle endurance was
measured through the craniocervical flexion test [28], and the strength of cervical flexors and extensors was measured by a special straight push pad of handheld dynamometer (Baseline Lite 200lb) which has shown to have a good interrater and intrarater reliability [29]. The pulmonary functions were measured through ‘Spirolab4” (MIR) in sitting position by a trained respiratory technician. The evidence of these tests is based on the official agreement between the American Thoracic Society and European Respiratory Society about the standardization of spirometry. Two pulmonary tests were performed (1) VC maneuver (2) FET (Forced expiratory technique) This maneuver included measurement of FEV1, FVC and FEV1/FVC ratio [30, 31]. The steps of the study are summarized in the CONSORT flow diagram (Fig 1).

Data analysis

The data were analyzed using the SPSS 21.0 (SPSS Inc., Chicago, USA). The collected data were assessed for normality using (Shapiro-Wilk test). For descriptive statistics, continuous variables were expressed as mean± SD (standard deviation), and for categorical variables frequencies and percentages were applied. For the inferential statistics, independent t-test and Mann–Whitney U test were used for between group comparison while Repeated measures ANOVA and Friedman test were applied for within group comparison at different time points (baseline, 4th and 8th week) and Bonferroni adjustment was used for pair wise comparison. For pair wise comparison of asymmetric variables at baseline, 4th and 8th week non parametric Wilcoxon signed rank test was used. The p value < 0.05 was considered as statistically significant for all analyzed data. All results were analyzed at 95% confidence interval.

Results

During eight weeks of intervention program, all 68 participants with chronic neck pain completed the study. There were no significant differences between groups in the mean age and BMI (Body Mass Index), pain, NDI, endurance, strength of neck muscles and pulmonary functions. The average age, height, weight and body mass index of participants in breathing reeducation group and routine physical therapy group were 39.71 ± 5.56 and 39.00 ± 4.90 years, 156.35 ± 4.64 and 156.44 ± 3.66 meters, 65.15 ± 6.96 and 63.86 ± 6.09Kg, 27.01 ± 1.67 and 26.67 ± 1.65Kg/m^2 respectively. Whereas number of female and male participants was 14 (41.20%) and 14 (38.90%), and male participant was 20 (58.80%) and 20 (61.10%) in breathing reeducation group and routine physical therapy group respectively (Table 1).

The results of repeated measure ANOVA for comparison in mean scores for cervical active range of motion (AROM) at different time points (4th and at 8th weeks) revealed a statistically significant difference with (F = 10.126; p < 0.001) (Table 2). At baseline, the mean cervical AROM scores in breathing reeducation group (BR) and routine physical therapy group (RPT) were flexion 36.59˚ ± 1.28, 36.25˚ ± 1.38 extension 50.26˚ ± 1.33, 50.39˚ ± 1.32, right lateral flexion 38.91˚ ± 1.31, 38.92˚ ± 1.36 left lateral flexion 39.91˚ ± 1.31, 39.70˚ ± 1.34 right rotation 50.47˚ ± 1.50, 50.86˚ ± 1.25 and left rotation 49.06˚ ± 1.92, 50.06˚ ± 1.98 respectively (Table 2).

The results of repeated measure ANOVA for evaluation of change in mean NDI score and endurance of neck flexors at different time points were statistically significant with (F = 6.857; P = 0.011) and (F = 4.308; P = 0.042) respectively (Table 2). The results of repeated measure ANOVA for evaluation of change in mean score for FEV1/FVC ratio were also significant with (F = 15.631; P = 0.001) (Table 2).

The multivariate analysis from repeated measure ANOVA for the interaction effect of group by time (group * time) showed that there was a statistical significant differences between breathing reeducation group and routine physical therapy group at baseline, 4th and 8th week. Time*group effect was significant in breathing reeducation group according to the p values.
and partial eta square values where \( (P < 0.001, 0.203) \) for cervical flexion and \( (P < 0.001, 0.36) \) for cervical extension, whereas non significant for right and left sided flexion \( (P > 0.001, \)
There was a significant group by time effect for NDI according to the p values and partial eta square values where \( P < 0.001, 0.199 \), endurance of neck muscles \( P < 0.001, 0.346 \) and FEV1/FVC ratio \( P < 0.001, 0.347 \) which showed that the NDI score showed more improvement in breathing reeducation group at 4th and 8th week as compared to routine physical therapy group. The endurance of cervical muscles and FEV1/FVC ratio showed statistically significant differences between breathing reeducation group and routine physical therapy group (Table 3). This difference is further explained with pair wise comparison of these outcome measures (Table 4).

Compared to the corresponding baseline values, the improvement in BR group was significantly greater than RPT group (intergroup mean difference for cervical flexion, -2.509; 95% CI, -2.85 to -2.193; \( P < 0.001 \) at 4th week and -4.682; 95% CI, -5.203 to -4.161; \( P < 0.001 \) at 8th week, after Bonferroni correction). The (intergroup mean difference for extension from baseline to 4th week was, -2.464; 95% CI, -2.789 to -2.139; \( P < 0.001 \) and -5.194; 95% CI, -5.744 to -4.645; \( P < 0.001 \) at 8th week, after Bonferroni correction) (Table 4). For cervical right side flexion (intergroup mean difference at baseline and at 4th week was, -2.323; 95% CI, -2.627 to -2.019; \( P < 0.001 \) and -4.088; 95% CI, -4.476 to -3.701; \( P < 0.001 \) at 8th week, after Bonferroni correction). For Left side cervical flexion (intergroup mean difference at baseline and at 4th week was, -2.127; 95% CI, -2.427 to -2.219; \( P < 0.001 \) and -4.124; 95% CI, -2.219 to -3.401; \( P < 0.001 \) at 8th week, after Bonferroni correction). For right side rotation of the cervical spine (intergroup mean difference at baseline and at 4th week was, -2.294; 95% CI, -2.640 to -1.949; \( P < 0.001 \) and -4.381; 95% CI, -4.882 to -3.879; \( P < 0.001 \) at 8th week, after Bonferroni correction) and for left side cervical rotation(intergroup mean difference at baseline and at 4th week was, -2.417; 95% CI, -2.815 to -2.019; \( P < 0.001 \) and -4.457; 95% CI, -4.993 to -3.920; \( P < 0.001 \) at 8th week, after Bonferroni correction) (Table 4).

Compared to the corresponding baseline values, the improvement in BR group was significantly greater than RPT group (intergroup mean difference for NDI, 3.076; 95% CI, 2.629 to -3.522; \( P < 0.001 \) at 4th week and 5.815; 95% CI, 5.170 to 6.460; \( P < 0.001 \) at 8th week, after Bonferroni correction) from baseline (Table 4). Compared to the corresponding baseline values, the improvement in BR group was significantly greater than RPT group (intergroup mean difference for endurance of neck flexors, -2.067; 95% CI, -2.307 to -1.827; \( P < 0.001 \) at 4th week and -4.4; 95% CI, -4.820 to -3.981; \( P < 0.001 \) at 8th week, after Bonferroni correction) from baseline (Table 4).
Compared to the corresponding baseline values, the improvement in BR group was significantly greater than RPT group (intergroup mean difference for FEV1/FVC ratio, -2.735; 95% CI, -3.109 to -2.361; P < 0.001 at 4th week and -5.668; 95% CI, -6.440 to -4.896; P < 0.001 at 8th week, after Bonferroni correction) (Table 4).

The between group comparison for pain through VAS (visual analogue scale) showed significant difference with P = 0.002* at 4th week P < 0.001* at 8th week from the baseline. The between group comparison for strength of cervical flexors and extensors showed significant difference with P = 0.120, P = 0.436 at 4th week and P < 0.001* and P = 0.034 at 8th week respectively from the baseline. The between group comparison for FVC showed significant difference with P = 0.012* at 4th week P < 0.001* at 8th week from the baseline and the between

### Table 2. Between groups comparison for CAROM, NDI, neck flexors endurance and FEV1/FVC ratio.

| Assessments                  | Breathing reeducation (n = 34) | Routine physical Therapy (n = 34) | Total (n = 68) | F      | P-Value | Partial Eta Square |
|------------------------------|--------------------------------|----------------------------------|----------------|--------|---------|-------------------|
| Flexion Baseline (Degree)    | 36.59±1.28                     | 36.25±1.38                       | 36.41±1.30     | 10.126 | 0.002*  | 0.13              |
| Flexion 4W (Degree)          | 39.41±1.50                     | 38.44±1.86                       | 38.91±1.80     |        |         |                   |
| Flexion 8W (Degree)          | 42.15±1.79                     | 40.05±2.18                       | 41.07±2.20     |        |         |                   |
| Extension Baseline (Degree)  | 50.26±1.33                     | 50.39±1.32                       | 50.33±1.32     | 4.99   | 0.029*  | 0.068             |
| Extension 4W (Degree)        | 52.97±1.93                     | 52.61±1.76                       | 52.79±1.84     |        |         |                   |
| Extension 8W (Degree)        | 56.76±2.77                     | 54.28±2.01                       | 55.49±2.70     |        |         |                   |
| Right Flexion Baseline (Degree) | 38.91±1.31                   | 38.92±1.36                       | 38.91±1.33     | 3.251  | 0.076   | 0.046             |
| Right Flexion 4W (Degree)    | 41.53±1.65                     | 40.94±1.72                       | 41.23±1.55     |        |         |                   |
| Right Flexion 8W (Degree)    | 43.59±1.65                     | 42.42±1.50                       | 42.99±1.67     |        |         |                   |
| Left Flexion Baseline (Degree) | 39.91±1.31                   | 39.70±1.34                       | 39.91±1.33     | 3.105  | 0.065   | 0.059             |
| Left Flexion 4W (Degree)     | 42.53±1.65                     | 41.11±1.42                       | 41.23±1.55     |        |         |                   |
| Left Flexion 8W (Degree)     | 44.59±1.65                     | 42.92±1.50                       | 42.99±1.67     |        |         |                   |
| Right Rotation Baseline (degree) | 50.47±1.50                  | 50.86±1.25                       | 50.67±1.38     | 0.693  | 0.408   | 0.011             |
| Right Rotation 4W (degree)   | 53.06±2.17                     | 52.86±1.78                       | 52.96±1.97     |        |         |                   |
| Right Rotation 8W (degree)   | 55.67±2.47                     | 54.42±2.23                       | 55.03±2.42     |        |         |                   |
| Left Rotation Baseline (degree) | 49.06±1.92                  | 50.06±1.98                       | 49.58±2.00     | 0.01   | 0.921   | 0.012             |
| Left Rotation 4W (degree)    | 52.06±2.39                     | 51.89±1.98                       | 51.97±2.17     |        |         |                   |
| Left Rotation 8W (degree)    | 54.50±2.62                     | 53.53±2.17                       | 54.00±2.43     |        |         |                   |
| NDI Score at Baseline        | 13.41±1.58                     | 13.14±1.76                       | 13.27±1.67     | 6.857  | 0.011*  | 0.092             |
| NDI Score at 4W              | 09.68±1.70                     | 10.72±1.39                       | 10.21±1.62     |        |         |                   |
| NDI Score at 8W              | 06.56±1.93                     | 8.36±1.87                        | 07.49±2.09     |        |         |                   |
| Endurance Neck Flexors at Baseline (mmHg) | 16.56±1.08                 | 16.75±1.48                       | 16.66±1.30     | 4.308  | 0.042*  | 0.06              |
| Endurance Neck Flexors at 4W (mmHg) | 18.97±1.24               | 18.47±1.75                       | 18.71±1.53     |        |         |                   |
| Endurance Neck Flexors at 8W (mmHg) | 21.97±1.60               | 20.14±2.06                       | 21.03±2.06     |        |         |                   |
| FEV1/FVC Ratio at Baseline (%) | 64.41±1.86                 | 64.31±2.32                       | 64.36±2.09     | 15.631 | <0.001* | 0.187             |
| FEV1/FVC Ratio at 4W (%)     | 67.88±1.81                     | 66.31±2.35                       | 67.07±2.23     |        |         |                   |
| FEV1/FVC Ratio at 8W (%)     | 71.97±2.10                     | 68.08±2.97                       | 69.97±3.23     |        |         |                   |

*indicates the statistical significant results.
The p-value was calculated by repeated measure ANOVA.
CAROM: Cervical active range of motion, NDI: Neck disability index, FEV1: Forced expiratory volume in one second, FVC: Forced vital capacity, Ratio: FEV1/FVC ratio, w: week.

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group comparison for FEV1 showed significant difference with $P = 0.267$ at 4\textsuperscript{th} week $P = 0.045$ at 8\textsuperscript{th} week from the baseline (Table 5).

The pairwise comparison for the variables pain, strength of cervical flexors, FVC and FEV1 through Wilcoxon signed rank test at baseline, at 4\textsuperscript{th} week and at 8\textsuperscript{th} week is shown in (Table 6).

**Discussion**

The present study was aimed to compare the effects of breathing reeducation on pain, cervical range of motion, disability, strength of neck muscles, endurance of neck muscles and pulmonary functions in patients with chronic neck pain. Breathing reeducation with routine physical therapy showed significant improvement in cervical and pulmonary outcomes from baseline to eight weeks. The improvement in pain, cervical flexion and extension range of motion (AROM), cervical flexor strength and neck disability index was significant in breathing reeducation group as compared to routine physical therapy group. The pulmonary functions of the patients were significantly improved in breathing reeducation group.

The results of this study are persistent to a review study about effects of breathing exercises on pain, quality of life and pulmonary functions in patients with chronic low back pain [32]. In this study best available researches were explored and there was a moderate evidence for the effectiveness of breathing exercises on pain, quality of life and pulmonary function in patients with chronic back pain. The results of the present study are also comparable to a study in which immediate effects of breathing reeducation were observed in 36 subjects with chronic neck pain. In the said study pain, cervical range of motion and chest expansion were evaluated before and immediately after the intervention and statistically significant improvement was found in the treatment group [17]. In contrast our study aimed to find out effects of breathing reeducation for eight weeks and outcomes were measured at baseline, 4th and at 8th week.
providing a more vast understanding about effects of breathing reeducation. In addition to pain and ROM, endurance, strength quality of life and pulmonary functions of patients with chronic neck pain were also assessed.

In a previous study effectiveness of neck stabilizing exercises combined with breathing reeducation exercises was assessed in 45 patients with stroke [33]. In the said study the effects of 30 minute exercise program was compared in two experimental and one control group. The conclusion of this study support our hypothesis as after six week evaluation only experimental group with combined regime of stabilizing exercises and breathing exercises showed improvement in neck flexors thickness, forced vital capacity and peak cough flow. In a cross sectional study on 44 neck pain patients and 31 healthy individuals, neck muscle strength was correlated to respiratory function of chronic neck pain patients i.e. more disability more dysfunction [34]. This correlation was evident in our study where combination of neck isometric exercises and breathing reeducation in patients with chronic neck pain resulted in improved strength of cervical muscles and improved pulmonary function.

| Outcome Measures | Combinations at different timepoints | Mean Difference | P-value | 95% Confidence Interval for Difference |
|------------------|-------------------------------------|----------------|---------|--------------------------------------|
|                  |                                     |                |         | Lower Bound                          |
| **Flexion (Degree)** | Baseline-4th Week          | -2.509         | <0.001* | -2.825                               |
|                  | Baseline-8th Week            | -4.682         | <0.001* | -5.203                               |
|                  | 4th Week-8th Week            | -2.173         | <0.001* | -2.558                               |
| **Extension (Degree)** | Baseline-4th Week          | -2.464         | <0.001* | -2.789                               |
|                  | Baseline-8th Week            | -5.194         | <0.001* | -5.744                               |
|                  | 4th Week-8th Week            | -2.73          | <0.001* | -3.171                               |
| **Right Flexion (Degree)** | Baseline-4th Week          | -2.323         | <0.001* | -2.627                               |
|                  | Baseline-8th Week            | -4.088         | <0.001* | -4.476                               |
|                  | 4th Week-8th Week            | -1.766         | <0.001* | -1.987                               |
| **Left Flexion (Degree)** | Baseline-4th Week          | -2.127         | <0.001* | -2.427                               |
|                  | Baseline-8th Week            | -4.124         | <0.001* | -4.176                               |
|                  | 4th Week-8th Week            | -1.689         | <0.001* | -1.287                               |
| **Right Rotation (Degree)** | Baseline-4th Week          | -2.294         | <0.001* | -2.640                               |
|                  | Baseline-8th Week            | -4.381         | <0.001* | -4.882                               |
|                  | 4th Week-8th Week            | -2.087         | <0.001* | -2.378                               |
| **Left Rotation (Degree)** | Baseline-4th Week          | -2.417         | <0.001* | -2.815                               |
|                  | Baseline-8th Week            | -4.457         | <0.001* | -4.993                               |
|                  | 4th Week-8th Week            | -2.04          | <0.001* | -2.331                               |
| **NDI Score** | Baseline-4th Week            | 3.076          | <0.001* | 2.629                                |
|                  | Baseline-8th Week            | 5.815          | <0.001* | 5.170                                |
|                  | 4th Week-8th Week            | 2.739          | <0.001* | 2.292                                |
| **Endurance Neck flexors (mmHg)** | Baseline-4th Week          | -2.067         | <0.001* | -2.307                               |
|                  | Baseline-8th Week            | -4.4           | <0.001* | -4.820                               |
|                  | 4th Week-8th Week            | -2.333         | <0.001* | -2.635                               |
| **FEV1/FVC Ratio (%)** | Baseline-4th Week          | -2.735         | <0.001* | -3.109                               |
|                  | Baseline-8th Week            | -5.668         | <0.001* | -6.440                               |
|                  | 4th Week-8th Week            | -2.933         | <0.001* | -3.472                               |

* * indicates the statistical significant results.

The p-value was calculated by repeated measure ANOVA.

FEV L/s: Force expiratory volume liter /second FVC: Force vital capacity.
Breathing reeducation is an effective regime to improve pulmonary functions of the patients with chronic neck and back pain [17, 32]. In a study on 40 healthy males (age 20–29 years) breathing exercises combined with upper extremity exercises resulted in significant improvement in FVC, whereas there were no significant intergroup differences in FEV1 and peak expiratory flow rate. The participants in the said study were divided in two groups, both groups received breathing exercises and the experimental group performed dynamic upper extremity exercises in addition to breathing exercises for four weeks [35]. The results of this study support our findings according to which the patients with chronic neck pain who were in breathing reeducation group showed significant improvement in FVC, FEV1 and FEV1/FVC ratio at four weeks and further improvement at eight weeks from the baseline. A recent study compared the effects of adding respiratory exercises in therapeutic routine for smartphone users with chronic neck pain and found it an effective treatment [36].

Table 5. Between and within group comparison for pain, strength of cervical flexors and extensors, FVC and FEV1 at baseline, 4th week and 8th week.

| Assessments                          | Interventions               | Mann-Whitney U | Z    | P-Value* |
|--------------------------------------|-----------------------------|----------------|------|----------|
|                                      | Breathing reeducation (n = 34) | Routine physical Therapy (n = 34) | Mean Rank |       |
| Pain score at Baseline               | 36.24                       | 34.81          | 587.00 | -0.31    | 0.754  |
| pain score at 4W                     | 27.90                       | 42.68          | 353.50 | -3.16    | 0.002* |
| pain score at 8W                     | 22.93                       | 47.38          | 184.50 | -5.18    | <0.001*|
| Chi Square value                     | 68.00                       | 69.39          |       |          |
| P-Value *                            | <0.001*                     | <0.001*        |       |          |
| Strength Flexion at Baseline         | 34.47                       | 36.47          | 577.00 | -0.43    | 0.665  |
| Strength Flexion at 4W               | 39.18                       | 32.03          | 487.00 | -1.55    | 0.120  |
| Strength Flexion at 8W               | 43.97                       | 27.50          | 324.00 | -3.48    | <0.001*|
| Chi Square value                     | 65.79                       | 69.39          |       |          |
| P-Value *                            | <0.001*                     | <0.001*        |       |          |
| Strength Neck Extensors at Baseline  | 34.47                       | 36.47          | 577.00 | -0.45    | 0.655  |
| Strength Neck Extensors at 4W        | 37.26                       | 33.83          | 552.00 | -0.78    | 0.436  |
| Strength Neck Extensors at 8W        | 40.50                       | 30.78          | 442.00 | -2.12    | 0.034* |
| Chi Square value                     | 67.51                       | 71.51          |       |          |
| P-Value *                            | <0.001*                     | <0.001*        |       |          |
| Forced Vital Capacity at Baseline    | 37.82                       | 33.31          | 533.00 | -1.01    | 0.314  |
| Forced Vital Capacity at 4W (Lt)     | 41.65                       | 29.69          | 403.00 | -2.52    | 0.012* |
| Forced Vital Capacity at 8W (Lt)     | 44.68                       | 26.83          | 300.00 | -3.71    | <0.001*|
| Chi Square value                     | 68.00                       | 72.00          |       |          |
| P-Value *                            | <0.001*                     | <0.001*        |       |          |
| One second Forced expiratory volume at Baseline | 33.28   | 37.60          | 536.50 | -1.10    | 0.271  |
| One second Forced expiratory volume at 4W (Lt) | 38.22 | 32.93          | 519.50 | -1.11    | 0.267  |
| One second Forced expiratory volume at 4W (Lt) | 40.47   | 30.81          | 443.00 | -2.01    | 0.045* |
| Chi Square value                     | 68.00                       | 62.44          |       |          |
| P-Value *                            | <0.001*                     | <0.001*        |       |          |

“*” indicates the statistical significant results.
“#” indicates the p-value calculated by non-parametric Friedman Test that is used for within group comparison at different time points (Baseline, 4th week and 8th week).
“+” indicates the p-value is calculated using Non-parametric Mann-Whitney U for between group comparison.
Chi square values are from Friedman’s chi square distribution table.

Breathing reeducation is an effective regime to improve pulmonary functions of the patients with chronic neck and back pain [17, 32]. In a study on 40 healthy males (age 20–29 years) breathing exercises combined with upper extremity exercises resulted in significant improvement in FVC, whereas there were no significant intergroup differences in FEV1 and peak expiratory flow rate. The participants in the said study were divided in two groups, both groups received breathing exercises and the experimental group performed dynamic upper extremity exercises in addition to breathing exercises for four weeks [35]. The results of this study support our findings according to which the patients with chronic neck pain who were in breathing reeducation group showed significant improvement in FVC, FEV1 and FEV1/FVC ratio at four weeks and further improvement at eight weeks from the baseline. A recent study compared the effects of adding respiratory exercises in therapeutic routine for smartphone users with chronic neck pain and found it an effective treatment [36]. In that study 60 patients (aged 24.7±2.1 years) from both genders were divided equally in three groups, pain,
muscle activity and respiratory parameters were measured before and at eight weeks of the treatment. There were significant improvements in the combined group compared with the therapeutic routine group (p = 0.03) for diaphragm muscle activation, (p = 0.03), neck erector spine activity (p = 0.04), respiratory balance (p = 0.04), and number of breaths (p = 0.02). The results of this study are consistent with our study where addition of breathing reeducation in routine physical therapy treatment resulted in improved pain, disability and pulmonary functions measured through spirometry. As compared to this study where respiratory parameters were measured through respiratory balance and number of breaths only, we used an authentic assessment approach measuring FVC, FEV1 and FEV1/FVC ratio through spirometry.

The present study is the first comprehensively designed clinical trial to investigate the efficacy of breathing reeducation with routine physical therapy in chronic neck pain patients. According to the results, breathing reeducation was found effective in improving cervical outcome measures, decreasing pain and disability level in chronic neck pain patients whereas pulmonary functions were also improved.

Limitations of the study

There are a few limitations of the study. Only forced expiratory technique (FET) and vital capacity (VC) were measured to assess pulmonary functions to avoid lengthy measurement procedures as patients with chronic neck pain were involved in the study. However, maximum voluntary ventilation (MVV) and chest expansion should have been measured to have a more understanding about effect of breathing reeducation on pulmonary function. Provided the lack of meticulously designed clinical trials on effect of breathing reeducation in chronic neck pain patients, multicenter pragmatic trials are required for the generalizability of the present findings in the treatment of chronic neck pain. Moreover, we recommend categorization of participants on the basis of breathing dysfunction prior to the breathing reeducation so that more understanding of the effects of breathing intervention among various categories can be understood.
Conclusion
Breathing reeducation combined with routine physical therapy treatment improves pain, cervical flexion and extension range of motion, endurance and strength of neck flexors in patients with chronic non specific neck pain moreover; it also improves disability, FVC, FEV1 and FEV1/FVC ratio in patients with chronic neck pain. Thus, breathing reeducation may be an effective regime to improve cervical and pulmonary outcomes in chronic neck pain patients.

Supporting information
S1 Checklist. Consolidated standards of reporting trials checklist. (DOC)
S1 File. Study protocol. (DOCX)
S1 Data. Study data. (XLSX)

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References
1. Todd A, McNamara CL, Balaj M, Huijts T, Akhter N, et al. (2019) The European epidemic: pain prevalence and socioeconomic inequalities in pain across 19 European countries. European Journal of Pain 23: 1425–1436. https://doi.org/10.1002/ejp.1409 PMID: 31038816
2. Kuo C, Sheffels J, Fanton M, Yu IB, Hamalainen R, et al. (2019) Passive cervical spine ligaments provide stability during head impacts. Journal of the Royal Society Interface 16: 20190086. https://doi.org/10.1098/rsif.2019.0086 PMID: 31138091
3. Ballenberger N, von Piekartz H, Paris-Alemany A, La Touche R, Angulo-Díaz-Parreño S (2012) Influence of different upper cervical positions on electromyography activity of the masticatory muscles. Journal of manipulative and physiological therapeutics 35: 308–318. https://doi.org/10.1016/j.jmpt.2012.04.020 PMID: 22632591
4. Zafar H, Alghadir AH, Iqbal ZA (2017) Effect of different head-neck-jaw postures on cervicocephalic kinesiesthetic sense. Journal of musculoskeletal & neuronal interactions 17: 341. PMID: 29199196
5. Liebsch C, Wilke H-J (2018) Basic biomechanics of the thoracic spine and rib cage. Biomechanics of the Spine: Elsevier. pp. 35–50.
6. Tsang SM, Szeto GP, Xie Y, Lee RY (2018) Association of electromyographic activation patterns with pain and functional disability in people with chronic neck pain. European journal of applied physiology 118: 1481–1492. https://doi.org/10.1007/s00421-018-3878-z PMID: 29730803
7. Kim K-s, Shin H-k (2019) Effects of Intra-Abdominal Pressure Training on Muscular Activity of Sterno-cleidomastoid and Upper Trapezius During Inspiration. 한국감정과학회국제학술대회 (ICES) 2019: 62–63.
8. Kahlaee AH, Ghamkhari L, Arab AM (2017) The association between neck pain and pulmonary function: a systematic review. American journal of physical medicine & rehabilitation 96: 203–210. https://doi.org/10.1097/PHM.0000000000000605 PMID: 27610549
9. Chaitow L, Gilbert C, Bradley D (2014) What are breathing pattern disorders. Recognizing and treating breathing disorders: a multidisciplinary approach. London, Churchill Livingstone: 1–10.
10. Dimitriadis Z, Kapreli E, Strimpakos N, Oldham J (2013) Hypocapnia in patients with chronic neck pain: association with pain, muscle function, and psychologic states. American journal of physical medicine & rehabilitation 92: 746–754.

11. Awadallah MF, Sobh E, Shendy MA, Al-Shenqiti AM, Al-Jeraisai TM, et al. (2021) Impaired pulmonary function in patients with chronic neck pain. Journal of Medical Sciences 41: 123.

12. Dimitriadis Z, Kapreli E, Strimpakos N (2016) Respiratory dysfunction in patients with chronic neck pain: What is the current evidence? Journal of bodywork and movement therapies 20: 704–714. https://doi.org/10.1016/j.jbmt.2016.02.001 PMID: 27814848

13. Kapreli E, Vourazanis E, Strimpakos N (2008) Neck pain causes respiratory dysfunction. Medical hypotheses 70: 1009–1013. https://doi.org/10.1016/j.mehy.2007.07.050 PMID: 17959320

14. Blanpied PR, Gross AR, Elliott JM, Devaney LL, Clewley D, et al. (2017) Neck pain: revision 2017: clinical practice guidelines linked to the international classification of functioning, disability and health from the orthopaedic section of the American Physical Therapy Association. Journal of Orthopaedic & Sports Physical Therapy 47: A1–A83.

15. Beltran-Alacreu H, Lopez-de-Uralde-Villanueva I, Fernandez-Camero J, La Touche R (2015) Manual therapy, therapeutic patient education, and therapeutic exercise, an effective multimodal treatment of nonspecific chronic neck pain: a randomized controlled trial. American journal of physical medicine & rehabilitation 94: 887–897. https://doi.org/10.1097/PHM.0000000000000293 PMID: 25886653

16. Busch V, Magrel W, Kern U, Haas J, Hajak G, et al. (2012) The effect of deep and slow breathing on pain perception, autonomic activity, and mood processing—an experimental study. Pain Medicine 13: 215–228. https://doi.org/10.1111/j.1526-4637.2011.01243.x PMID: 21939499

17. Yeampattanaporn O, Mekhora K, Jalayondeja W, Wongsathikun J (2014) Immediate effects of breathing re-education on respiratory function and range of motion in chronic neck pain. Journal of the Medical Association of Thailand = Chotmaihet Thangphaet 97: S55–S59. PMID: 25141528

18. Kang J-I, Jeong D-K, Choi H (2016) The effect of feedback respiratory exercise on muscle activity, craniovertebral angle, and neck disability index of the neck flexors of patients with forward head posture. Journal of physical therapy science 28: 2477–2481. https://doi.org/10.1589/jpts.28.2477 PMID: 27799674

19. Mohan V, Ahmad NB, Tambi NB (2016) Effect of respiratory exercises on neck pain patients: A pilot study. Polish Annals of Medicine 23: 15–20.

20. Schulz KF, Altman DG, Moher D (2010) CONSORT 2010 statement: updated guidelines for reporting parallel group randomised trials. Trials 11: 1–8.

21. Duymaz T (2019) Effect of physiotherapy on respiratory functions in patients with chronic neck pain. Anal Med 10: 724–727.

22. Riss I, Juul-Kristensen B, Boyle E, Kongsted A, Manniche C, et al. (2017) Chronic neck pain patients with traumatic or non-traumatic onset: Differences in characteristics. Scandinavian journal of pain 14: 1–8. https://doi.org/10.1016/j.sjpain.2016.08.008 PMID: 28850421

23. Paine NJ, Joseph MF, Bacon SL, Julien CA, Cartier A, et al. (2019) Association between depression, lung function, and inflammatory markers in patients with asthma and occupational asthma. Journal of occupational and environmental medicine 61: 453–460. https://doi.org/10.1097/JOM.0000000000001562 PMID: 30855523

24. Park Y, Jung JY, Kim YS, Chung KS, Song JH, et al. (2018) Relationship between depression and lung function in the general population in Korea: a retrospective cross-sectional study. International journal of chronic obstructive pulmonary disease 13: 2207. https://doi.org/10.2147/COPD.S169025 PMID: 30140153

25. Alaparthi GK, Augustine AJ, Anand R, Mahale A (2016) Comparison of diaphragmatic breathing exercise, volume and flow incentive spirometry, on diaphragm excursion and pulmonary function in patients undergoing laparoscopic surgery: a randomized controlled trial. Minimally invasive surgery 2016. https://doi.org/10.1155/2016/1967532 PMID: 27525116

26. Collins SL, Moore RA, McQuay HJ (1997) The visual analogue pain intensity scale: what is moderate pain in millimetres? Pain 72: 95–97. https://doi.org/10.1016/s0304-3959(97)00005-5 PMID: 9272792

27. Farooq MN, Mohsani-Bandpei MA, Gilani SA, Hafeez A (2017) Urdu version of the neck disability index: a reliability and validity study. BMC musculoskeletal disorders 18: 1–11.

28. Juli GA, O'leary SP, Falla DL (2008) Clinical assessment of the deep cervical flexor muscles: the cranio-cervical flexion test. Journal of manipulative and physiological therapies 31: 525–533. https://doi.org/10.1016/j.jmpt.2008.08.003 PMID: 18804003

29. Vannebo KT, Iversen VM, Finland MS, Mork PJ (2018) Test-retest reliability of a handheld dynamometer for measurement of isometric cervical muscle strength. Journal of back and musculoskeletal rehabilitation 31: 557–565. https://doi.org/10.3233/BMR-170829 PMID: 29526841
30. Miller MR, Hankinson J, Brusasco V, Burgos F, Casaburi R, et al. (2005) Standardisation of spirometry. European respiratory journal 26: 319–338. https://doi.org/10.1183/09031936.05.00034805 PMID: 16055882

31. Levy ML, Quanjer PH, Rachel R, Cooper BG, Holmes S, et al. (2009) Diagnostic Spirometry in Primary Care: Proposed standards for general practice compliant with American Thoracic Society and European Respiratory Society recommendations. Primary Care Respiratory Journal 18: 130–147.

32. Anderson BE, Bliven KCH (2017) The use of breathing exercises in the treatment of chronic, nonspecific low back pain. Journal of sport rehabilitation 26: 452–458. https://doi.org/10.1123/jsr.2015-0199 PMID: 27632818

33. Lee M-H, Hwang-bo G (2015) Effects of the neck stabilizing exercise combined with the respiratory reeducation exercise on deep neck flexor thickness, forced vital capacity and peak cough flow in patients with stroke. Physical Therapy Korea 22: 19–29.

34. López-de-Uralde-Villanueva I, Sollano-Valle E, Del Corral T (2018) Reduction of cervical and respiratory muscle strength in patients with chronic nonspecific neck pain and having moderate to severe disability. Disability and rehabilitation 40: 2495–2504. https://doi.org/10.1080/09638288.2017.1337239 PMID: 28604165

35. Han JW, Kim YM (2018) Effect of breathing exercises combined with dynamic upper extremity exercises on the pulmonary function of young adults. Journal of Back and Musculoskeletal Rehabilitation 31: 405–409. https://doi.org/10.3233/BMR-170823 PMID: 28946539

36. Dareh-deh HR, Hadadnezhad M, Letafkar A, Peolsson A (2020) Effects of Adding Respiratory Exercises to the Therapeutic Routine in Smartphone Users With Forward Head Posture and Non-Specific Chronic Neck Pain: A Randomised Controlled Trial. Researchsquare 1: 1–16.