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# Effect of respiratory exercises on neck pain patients: A pilot study

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ABSTRACT

*Introduction:* Neck exercises are reported to improve the patient's conditions in chronic neck pain (CNP). However, the existence of pain and loss of range of motion often results in CNP. As a result, respiratory functions are compromised and extended rehabilitation may be required for respiratory parameters among these populations.

*Aim:* The purpose of this study was to analyze the effects of respiratory exercises on respiratory muscle endurance, cervical range of motion and chest expansion after a set of prescribed respiratory exercise procedure among CNP.

*Material and methods:* Ten patients with CNP participated in this study. Subjects were divided randomly into either an experimental group, which received respiratory exercises or a control group, which received a routine physiotherapy exercises. The outcome measures such as pain, respiratory muscle endurance, cervical range of motion and chest expansion were assessed before and eight weeks following treatment by an assessor blinded to the treatment allocation of the patient.

*Results and discussion:* There was a highly significant increase in maximum voluntary ventilation (MVV) scores from before (mean 34.88, SD 21.81) to after treatment (mean 55.10, SD 16.76 and *t*-value 6.48) with $P = 0.003$ in the experimental group as compared to control group from before (mean 38.32, SD 19.50) to after treatment (mean 39.74, SD 17.56 and *t*-value 0.845) with $P = 0.446$. The two sets of scores in the active flexion and for the visual analogue scale also showed significant difference in the experimental group $P < 0.05$.

*Conclusions:* Respiratory exercise contributes to improvement in respiratory muscle endurance and reduces pain who is enduring from CNP.



## 1. Introduction

Neck pain is a common clinical context which happens in everybody's life. It ranked fourth highest in terms of disability and its accounts to 33.6 million in 2010 as reported by the global burden of neck pain.[1] It has been hypothesized and demonstrated that the chronic neck pain (CNP) patients presents a weakness of their respiratory muscles.[2,3] Similarly, studies have expressed that patient with CNP exhibited

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reduced neck muscle strength, chest expansion, endurance, maximal inspiratory and expiratory pressure.[4,5] These findings further fortify the impression that the chronic neck pain population presents a weakness of respiratory muscles.

Analyzing the motor control of neck by means of assessing respiratory muscles through a concept of kinetic control which was proposed for lumbar spine could be considered as a mode of assessing neck pain population.[6] The motor weakness in the respiratory muscles may alter the pattern of breathing, resulting in asymmetrical breathing and worsens the chest wall mechanics. This asymmetrical breathing places the respiratory muscles and accessory muscles of respiration at a mechanical disadvantage state by decreasing the respiratory muscle endurance. Hence, instructing appropriate breathing strategy for regulating the respiratory pattern may alter the breathing by means of promoting symmetry on the chest wall thereby it may encourage respiratory muscle endurance to improve. Research findings have also indicated implementation of respiratory function assessment and exercises into the routine practice for patients who are suffering from CNP.[3–5]

So far, respiratory exercises have been attempted on chronic obstructive pulmonary diseases (COPD), spinal cord injury and myasthenia gravis population using breathing exercises and with the help of devices.[7–10] Devices which are available in the routine use are of different varieties such as incentive spirometry device and portable re-breathing device. Portable re-breathing device demands the subjects to execute normocapnic hyperpnea training and incentive spirometry (IS) necessitates the subjects to perform breathing in and out through the mouthpiece. These kinds of respiratory exercises are proven to be effective in different clinical situation. However, these forms of exercises as indicated by earlier research have not been applied on CNP population. Considering those factors, merits and disadvantage of the exercises, we have designed an exercise protocol in specific to the respiratory muscle using volume oriented device incentive spirometer (VODIS).

## 2. Aim

The main aim of the study was to investigate the effect of respiratory muscle endurance training on respiratory and musculoskeletal parameters among patients with CNP.

## 3. Material and methods

### 3.1. *Subjects*

A total of 10 subjects (2 males and 8 females) aged 22–79 years old ($48.50 \pm 18.53$) participated in the study. The body mass index (BMI) of the subjects was $25.94 \pm 3.18$ kg/m$^2$. All the patients were recruited from a Ministry Hospital in Malaysia and were able to comprehend English with secondary and tertiary level education. The subjects who had a history of CNP with or without headache for more than three months and free from respiratory and cardiac illness were recruited. Subjects who had a past history of surgery to the cervical spine and those who participated in physiotherapy exercise program were excluded from the present study. This study was approved by the institutional review and ethics board of the University and from the Ministry. Informed consent was obtained from all the participants prior to the study. Prior to grouping, the subjects were indulged in completing the demographic details. After obtaining the demographic details based on systematic sampling procedures, they were allotted to experimental ($N = 5$) and control groups ($N = 5$) through single blinding procedures in which the investigator who collected the data knows whether the subjects are in the control group or in the experimental group.

### 3.2. *Measurement tools*

#### 3.2.1. *Chest expansion*

It was evaluated at axilla, fourth intercostal space and xiphoid level using a cloth tape measure. The measurement in centimeters was taken at peak inhalation and peak exhalation and this method of measurement was proved to be reliable.[11]

#### 3.2.2. *Respiratory muscle endurance testing*

It was carried out using a hand held spirometry (Pony Fx Cosmed, Italy). Details such as age, height and weight using SECA weight and height scale (Vogel&Halke, Hamburg, Germany) were keyed in to the handheld spirometer before performing the test. Respiratory muscle endurance testing was tested using MVV indices ($MVV_{ind}$). The subjects were instructed to breathe in and out forcibly through the spirometry for a period of 15 s and the readings were calculated automatically by the equipment for a minute. The maneuver was performed three times in front of the spirometer and the best readings were accounted.[12]

#### 3.2.3. *Cervical range of motion*

It was measured using a universal goniometer. The participants were initially positioned in the chair with back support, the knees positioned at 90° as reported in an earlier study.[13] The measurement of cervical flexion, extension, lateral flexion and rotation for both sides are carried out using an operationally defined goniometric placement as reported in an earlier study and this method is found to have greater reliability.[14]

#### 3.2.4. *Neck disability index*

The measure of activity limitation for neck pain was measured using an English version of neck disability index (NDI) which consists of 10 sections of questions. The scoring was categorized into five stages ranging from minimal disability to cripple and it was carried out by a physiotherapist. The method of scoring demonstrated a high degree of reliability and internal consistency.[15]

#### 3.2.5. *Graduated numbered visual analogue scale (GN-VAS)*

Pain was rated using graduated numbered visual analogue scale (GN-VAS) in which subjects rated each pain on a 1–10 scale. A rating of 10 on the scale is being considered as severe pain as reported in earlier literatures. The readings of all these outcome measures were taken initially as baseline readings and after eight weeks following training programs.[16,17]

### 3.3. Procedures

Subjects in both the groups received routine physiotherapy sessions with the help of electrotherapeutic modalities, stretching, range of motion exercises and they were educated to perform these exercises in the home. The compliance was monitored verbally. The respiratory exercise programs for the experimental groups were diaphragmatic breathing exercises (DBE), VODIS and pursed lip breathing exercises.

DBE was taught by placing the subject comfortably positioned with either therapist or the patient's hand directed over the abdominal area and instructing the subjects to focus on an outward movement of the abdominal area throughout inspiration and an inward movement of the abdominal area during expiration. Inspiration is aimed through the nose and expiration through the mouth.[12,18]

Then for the VODIS (Coach 2 device, DHD healthcare, Canastota, NY) the participants were instructed to hold the device, exhale normally, and then maintain the mouthpiece tightly around the lips. Subsequently the subjects were instructed to inhale deeply and slowly, hold their breath at maximal inspiration for at least 5 s and exhale normally without mouthpiece and this was performed in accordance with clinical practice guideline, 2011.[6,16,19] Pursed lip breathing exercises were performed by necessitating the subjects to inhale through their nose and then exhaling slowly for a period of 4–6 s by pursing the lips.[8,20]

Each of the exercises in the respiratory exercise program were demonstrated initially as a part of orientation and these exercises are carried out with supervision two times per week for a period of 8 weeks along with routine physiotherapy sessions. Each session lasted for about 40 min for both the group. Confounding factors such as gender, race and occupation were not eliminated for data analysis as the study was a preliminary study with a small number of samples.

## 4. Results

Data distribution was tested by Shapiro–Wilk tests and was normal for all apart from nipple and xiphoid level for chest expansion. Data are not normally distributed for active flexion, extension, right side rotation, VAS scale and for a passive cervical range of motion, such as extension, right and left side rotation with $P > 0.05$.

Demographic characteristics of study samples are presented in Table 1. In order to compare the mean scores for the groups, independent *t*-test was used for parametric data and for non-parametric data Mann–Whitney *U*-tests were used. Their clinical backgrounds and the results of their baseline respiratory and musculoskeletal parameters are presented in Table 2. MVV and chest expansion readings were somewhat lower in the experimental group, but these differences did not reach a statistically significant level. Cervical movements of active flexion and passive left side rotation were significantly reduced in the experimental group when compared to the control group subjects.

The two sets of scores in the active flexion and for the visual analogue scale showed a significant difference in the experimental group. Similarly, for the control group the two sets of scores in active flexion, extension and passive extension showed significant difference with $P < 0.05$. However, there were no changes reported in remaining variable which showed there is no effect on the treatment (Table 3).

In the experimental group, there was a significant increase in MVV scores from before treatment (34.88 ± 21.81) to after treatment (55.10 ± 16.76) with $t = 6.488$ and $P = 0.003$. Therefore, it can be concluded that respiratory muscle endurance training showed a significant increase in the MVV scores. Similarly, there was a significant increase in active left side rotation, passive flexion from before treatment (41.00 ± 5.48; 32.00 ± 7.58, respectively) to after treatment (54.10 ± 10.84; 48.00 ± 5.70,

**Table 1 – Demographic characteristics of study population.**

| Variables | Experimental (N = 5) Mean ± SD | Control (N = 5) Mean ± SD |
|---|---|---|
| *Age, years* | 48.50 ± 18.53 | |
| *Height, m* | 157.80 ± 9.43 | |
| *Weight, kg* | 64.15 ± 5.27 | |
| *BMI, kg/m²* | 25.94 ± 3.18 | |
| *Gender* | | |
| Male | – | 2 |
| Female | 5 | 3 |
| *Race* | | |
| Malay | 5 | 1 |
| Chinese | – | 1 |
| Indian | – | 3 |

**Table 2 – Baseline characteristics of respiratory and musculoskeletal parameters between neck pain group.**

| Variables | Experimental Mean ± SD | Control Mean ± SD | P value |
|---|---|---|---|
| *Chest expansion* | | | |
| Axilla, cm | 1.4 ± 0.6 | 1.90 ± 0.7 | 1.000 |
| Nipple, cm | 1.1 ± 0.5 | 1.40 ± 0.7 | 0.690 |
| Xiphoid, cm | 0.8 ± 0.2 | 1.0 ± 0.5 | 0.548 |
| *MVV, L/min* | 34.8 ± 21.8 | 38.3 ± 19.5 | 0.951 |
| **Active cervical range of motion** | | | |
| *Flexion, °* | 25 ± 3.5 | 32 ± 4.4 | **0.032** |
| *Extension, °* | 26 ± 5.4 | 31 ± 13.8 | 0.690 |
| Right side flexion, ° | 32 ± 8.3 | 28 ± 5.7 | 0.415 |
| Left side flexion, ° | 30 ± 9.3 | 32 ± 5.7 | 0.683 |
| Right side rotation, ° | 42 ± 2.7 | 42 ± 9.7 | 0.421 |
| Left side rotation, ° | 41 ± 5.4 | 48 ± 7.5 | 0.453 |
| **Passive cervical range of motion** | | | |
| *Flexion, °* | 32 ± 7.5 | 36 ± 5.4 | 0.504 |
| *Extension, °* | 35 ± 6.1 | 36 ± 13.8 | 1.000 |
| Right side flexion, ° | 38 ± 8.3 | 34 ± 7.4 | 0.683 |
| Left side flexion, ° | 37 ± 6.7 | 37 ± 5.7 | 0.495 |
| Right side rotation, ° | 47 ± 2.7 | 48 ± 7.5 | 0.421 |
| Left side rotation, ° | 48 ± 2.7 | 54 ± 8.2 | **0.014** |
| NDI | 22.5 ± 9.6 | 22 ± 8.8 | 0.873 |
| GN-VAS, cm | 5.4 ± 0.5 | 6.2 ± 1.7 | 0.136 |

*Note*: MVV – maximum voluntary ventilation, NDI – neck disability index, GN-VAS – graduated numbered visual analogue scale. Bold indicates significant results ($P < 0.05$).

**Table 3 – Comparison of pre and post variables among experimental and control groups.**

| Variables | Experimental | | Control | |
|---|---|---|---|---|
| | Z value | P value | Z value | P value |
| *Chest expansion* | | | | |
| Nipple, cm | −0.828 | 0.408 | 0.000 | 1.000 |
| Xiphoid, cm | −1.414 | 0.157 | 0.000 | 1.000 |
| *Active cervical range of motion* | | | | |
| Flexion, ° | −2.032 | **0.042** | −2.121 | **0.034** |
| Extension, ° | −1.841 | 0.066 | −2.121 | **0.034** |
| Right side rotation, ° | −1.089 | 0.276 | −1.633 | 0.102 |
| *Passive cervical range of motion* | | | | |
| Extension, ° | −0.962 | 0.336 | −2.121 | **0.034** |
| Right side rotation, ° | −1.786 | 0.074 | −1.633 | 0.102 |
| Left side rotation, ° | −1.857 | 0.063 | −1.414 | 0.157 |
| GN-VAS, cm | −2.023 | **0.041** | −1.732 | 0.083 |

*Note:* GN-VAS – graduated numbered visual analogue scale. Bold indicates significant results ($P < 0.05$).

**Table 4 – Comparison of pre and post values of experimental group (paired *t*-test).**

| Variables | Paired differences | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|
| | Mean | SD | | | |
| *Axilla* | −0.8000 | 0.7583 | −2.359 | 4 | 0.078 |
| *MVV* | −20.2200 | 6.9683 | −6.488 | 4 | **0.003** |
| *Active ROM* | | | | | |
| Right side flexion | −9.000 | 8.944 | −2.250 | 4 | 0.088 |
| Left side flexion | −12.000 | 10.368 | −2.588 | 4 | 0.061 |
| Left side rotation | −13.000 | 8.367 | −3.474 | 4 | **0.025** |
| *Passive ROM* | | | | | |
| Flexion | −16.000 | 12.450 | −2.874 | 4 | **0.045** |
| Right side flexion | −7.000 | 8.367 | −1.871 | 4 | 0.135 |
| Left side flexion | −8.000 | 6.708 | −2.667 | 4 | 0.056 |
| NDI | 15.19800 | 13.99826 | 2.428 | 4 | 0.072 |

*Note:* MVV – maximum voluntary ventilation, ROM – range of motion, NDI – neck disability index. Bold indicates significant results ($P < 0.05$).

respectively) with $P < 0.05$, whereas for the remaining variables, there were no significant changes statistically with $P > 0.05$ (Table 4).

In the control group, there was no significant increase in MVV scores from before treatment ($38.32 \pm 19.50$) to after treatment ($39.74 \pm 17.56$) with a $t = 0.845$ and a $P = 0.446$ (Table 5). Therefore, it can be concluded that respiratory muscle endurance did not increase significantly in the MVV scores of the control group, whereas for the active right side flexion, left side flexion and passive left side flexion there was a significant increase in the scores with $P < 0.5$.

**Table 5 – Comparison of pre and post values of control groups (paired *t*-test).**

| Variables | Paired differences | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|
| | Mean | SD | SEM | | | |
| *MVV* | −1.4200 | 3.7593 | 1.6812 | −0.845 | 4 | 0.446 |
| *Active range of motion* | | | | | | |
| Right side flexion | −9.000 | 4.183 | 1.871 | −4.811 | 4 | **0.009** |
| Left side flexion | −7.000 | 2.739 | 1.225 | −5.715 | 4 | **0.005** |
| Left side rotation | −3.000 | 2.739 | 1.225 | −2.449 | 4 | 0.070 |
| *Passive range of motion* | | | | | | |
| Flexion | −7.000 | 2.739 | 1.225 | −5.715 | 4 | **0.005** |
| Right side flexion | −6.000 | 5.477 | 2.449 | −2.449 | 4 | 0.070 |
| Left side flexion | −5.000 | 3.536 | 1.581 | −3.162 | 4 | **0.034** |
| NDI | 1.156 | 2.750 | 1.230 | 0.940 | 4 | 0.400 |

*Note:* MVV – maximum voluntary ventilation, NDI – neck disability index. Bold indicates significant results ($P < 0.05$).

## 5. Discussion

This study sets out with the intention of evaluating the importance of respiratory exercises among CNP patients. The general findings of this pilot study indicated that patients who are enduring from CNP improved respiratory muscle endurance parameters (MVV) with the aid of a designed protocol. Another important finding is that the pain level in the experimental group reduced as compared to control group, whereas cervical ROM variables did not improve as compared to control group. Similarly, chest expansion also did not establish any alterations between both the groups. Baseline characteristics of respiratory and musculoskeletal parameters were comparable between the groups except for the active flexion and passive left side rotation. The results demonstrated that 40 min of breathing exercises, pursed lip breathing exercises and VODIS exercises along with routine physiotherapy session two times per week over a period of 8 weeks promoted the variables studied.

The results of the present study in relation to respiratory muscle endurance among CNP subjects are consistent with the earlier studies in which the population studied are COPD, spinal cord injury and myasthenia gravis.[6–9] In contrast, the type of respiratory devices which was utilized in the present study was different from earlier studies as these studies utilized devices which offer more resistance as compared to VODIS to promote respiratory muscle endurance.[7–10] VODIS, which is considered in the present study, offers minimal airflow resistance as the purpose of the study was to implement respiratory exercises among CNP populations. Pursed lip breathing exercises are a technique prescribed for pulmonary disease population and it has been proposed that it will increase the recruitment pattern of respiratory muscles.[17] Hence, we estimated that inclusion of this exercise in the protocol of respiratory exercises might promote respiratory parameters and this is the reason pursed lip breathing has been admitted in the present study.

The reality that pain intensity level was detected to be diluted, also established respiratory exercises were proved to be an effective tool. This reveals that the function of sternocleidosmastoid, scalene and trapezius would have improved and provided postural stability followed by training and this has been reported to be weak among these subjects.[4] The graduated numbered VAS scale was also used to score the pain intensity for NDI. Even though this component of measurement in NDI showed positive changes, the baseline and post values of the total scores did not change. One unanticipated findings was that the cervical range of motion did not show convinced changes except for the active flexion of range of motion in the experimental group.

A possible limitation of these results may be the lack of appropriate instrument used for measuring cervical range of motion. The utility of equipments such as an inclinometer, bubble goniometer, cervical range of motion goniometer would have attained worthy results between the groups.[13,21,22] Hence, quantification of appropriate amount of range of motion using an appropriate valid outcome measure for the cervical range of motion is recommended for future studies. Another possible limitation of the study results in relation to cervical range of motion can be attributed to the study protocol which was designed. The protocol was designed particularly for respiratory exercises rather than having specific focussing on cervical range of motion. Similarly, neck muscle adiposity, which was associated with lower respiratory muscle endurance could be an important variable and is considered as one of the limitation of the present study.[21,23] Hence, testing these protocols with an appropriate outcome measure for cervical range of motion for future directions are recommended. Possibility of Bias such a selection bias while planning the study and performance bias while carrying out the study have not been overwhelmed as the study was meant to pilot the protocol. We believe that our pilot data yielded rationale for further exploration of this phenomenon in a randomized control trial with a larger sample size and long term follow up to know the carry over effect of the study results. This will reveal whether the protocol is a valuable tool in rehabilitation of individuals with neck pain.

## 6. Conclusion

This preliminary study found that respiratory muscle endurance improved following a predesigned respiratory exercise program among CNP population. Hence, it can be concluded from the pilot study that respiratory exercises can therefore be considered as a component of the exercises along with routine exercises for those peoples who are ailing from CNP.

## Conflict of interest

None declared.

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