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Effectiveness of strengthening deep cervical flexors using pressure biofeedback on vertical mandibular opening & craniovertebral angle in young adults with forward head posture - An experimental study

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ABSTRACT

Background and objectives. Forward head posture is associated with weakness in deep cervical short flexor & shortening of the opposing cervical extensor & Pectoralis muscles. Deep cervical flexor (DCF) has a major postural function in supporting and straightening the cervical lordosis. There were few studies on the correlation between craniovertebral angle & vertical mandibular opening. So there was a need to evaluate the effect of deep cervical muscle strengthening on forward head posture and vertical mandibular opening and find out the correlation between vertical mandibular opening (VMO) and craniovertebral angle(CVA).

Materials and methods. A total of 84 subjects were included in an experimental study. Subjects were screened according to the inclusion and exclusion criteria. Selected CVA were assessed using MB ruler software (ICC= 0.88). Selected VMO was measured using a ruler (ICC= 0.95-0.96). Subjects received DCF strengthening using pressure biofeedback, 2 sets of 10 repetitions, 5 days per week for 4 weeks. "Paired t test" was used within the group to test the change in quantitative data, pre-intervention and post-intervention. For the correlation between VMO & CVA, Pearson's correlation coefficient test was used.

Results. Strengthening of DCF using pressure biofeedback was effective in improving CVA & VMO (p value <0.0001) and moderate the positive correlation (r=0.4509) exist between CVA & VMO (p value <0.0001).

Conclusions. The study concluded that strengthening of deep cervical flexors using pressure biofeedback is effective on improving vertical mandibular opening & craniovertebral angle in young adults (18-30 years) with forward head posture.

Keywords: craniovertebral angle, deep cervical flexors, forward head posture, pressure biofeedback, vertical mandibular opening

List of abbreviations (in alphabetical order):

CVA – Craniovertebral angle
VMO – Vertical mandibular opening

INTRODUCTION

The Posture Committee of the American Academy of Orthopedic Surgeons defines good posture as "the state of muscular and skeletal balance which protects the supporting structures of the body against injury or progressive deformity, irrespective of the position (erect, lying, squatting, or stooping) in which these structures are working or resting" [1,2]. Proper postural alignment when sitting and standing allows efficient work with minimal fatigue and strain on body ligaments and muscles [3-5].

Forward head posture increases extension of atlanto-occipital joint and upper cervical as well as

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flexion of lower cervical and upper thoracic vertebrae, this posture causes persistent and abnormal contraction of the suboccipital, neck, and shoulder muscles. In forward head posture, center of gravity (COG) of the head shifts in anterosuperior direction, increasing the load on the neck which causes dysfunction of musculoskeletal system. The muscles around the head and shoulder, including the trapezius, sternocleidomastoid, suboccipital, and temporal are affected by forward head posture, which further worsen postural deformity. These changes cause persistent and abnormal pressure in the muscles, fascia, and nerves of the neck and shoulders and rounding of shoulder occurs to compensate for this deficit, which in turn, causes high load on the superior trapezius and levator scapulae muscles [6,7].

A study carried out by Griegel –Morris P, et al. on incidence of common postural abnormalities in the cervical, shoulder and thoracic regions and their association with pain in two age groups of healthy subjects conclude that there was 66% incidence of forward head posture between the age group of 20 – 35 years and also revealed that forward head posture had an increased incidence of cervical pain [8]. Forward Head Posture is commonly evident in people,

- repeatedly using computers,
- watching television,
- playing video games,
- using smart phones,
- using heavy backpacks and
- lying on improperly placed pillows

With FHP there also occurs affection to cervical joint position sense. A study by Pinsault et al. wherein cervical joint proprioception was assessed using cervicocephalic relocation test to the neutral head position has shown to degradation of cervical proprioception along with muscular fatigue [9].

The resting position of mandibular plays important role to produce movement of vertical mandibular opening. In resting position of mandible, the lip is in light contact or slightly apart, the opposing teeth are separated, all the jaw muscles are at rest function and the mandible is passively suspended against gravity. To determine if there is a limitation in mandibular movement, it is necessary to know the physiological Range of motion. Vertical mandibular opening is measured by Interincisal distance between edges of right upper and lower central incisors as measurement with a millimeter ruler. The normal mandibular opening of young adults is between 35 to 50 mm i.e. 3.5 to 5 cm. But the functional opening is 25 to 35 mm i.e. 2.5 to 3.5 cm or at least two knuckles between teeth. When the resting vertical dimension is altered, as clinically observed with faulty posture, it encroaches the freeway space, the mandibular condyle may intrude upward and backward in glenoid fossa. The teeth may be in contact eliminating the rest position and creating tension on the muscle of mastication and stress on teeth and supporting structures. It has been demonstrated that cervical muscle influences masticatory muscle activity. The influence of posture and stress on musculoskeletal pain and dysfunction is a prime etiologic factor that is commonly overlook [10].

Forward head posture associated with weakness in deep cervical short flexor muscles, and mid thoracic scapular retractor (i.e. rhomboids, middle and lower fibers of trapezius) and shortening of the opposing cervical extensor and Pectoralis muscles.

Forward head posture mostly occurs by the weakness of the anterior cervical neck flexor muscles which result in tightness of the sternocledomastoid [11-16]. The functional association between craniovertebral angle and vertical mandibular opening is still controversial according to clinical studies and due to the method differences. Craniocervical flexormuscle training enhances ability and improves neuromuscular control of the deep cervical flexor muscles, including the longus colli and longus capitis. Numerous studies using craniocervical flexor exercise as a treatment have led to a reduction in pain and neck disability, and also enhanced activation of the deep and superficial cervical flexor [17-21]. The objectives of the study was to find out effectiveness of deep cervical flexors strengthening for 4 weeks on vertical mandibular opening & craniovertebral angle on young adults with forward head posture, and to explore correlation between vertical mandibular opening and craniovertebral angle of young adults with forward head posture.

MATERIALS AND METHODS

An experimental study is carried out at Mvp's college of physiotherapy, Nashik after receiving the approval from Institutional Ethical Committee Mvp's College of Physiotherapy. The purpose and procedure of the study was explained to the participants. Subjects were screened according to the inclusion and exclusion criteria. Informed consent was obtained from selected subjects.

Inclusion criteria: Subjects with informed consent, age group of 18-30 years of age, both genders, all subjects having forward head posture (CVA less than 49º).

Exclusion criteria: Any history of trauma of the cervical region, history of cervical spine pathology, history of dizziness and vertigo, postural abnormalities like scoliosis, torticollis, known medical problems like rheumatic arthritis, ankylosing spondylitis and tuberculosis of spine, bones or joints, painful temporomandibular joint (TMJ), any popping sound or locking of temporomandibular joint, difficulty with functional activities of temporomandibular joint, like chewing, talking, yawning.

Withdrawl criteria: Participants who were not willing to participate or not able to perform tests included in the study due to pain were given complete freedom to withdraw from the study.

A total of 84 patient were included in the study. 8 patients were not able to complete intervention program and follow up, so they were dropped out from study. 76 subjects were recruited. Selected participants head posture (craniovertebral angle) were assessed using a valid and reliable photogrammatic method – **MB ruler software (ICC = 0.88)**. Selected participants **vertical mandibular opening** was measured using a millimeter ruler (ICC= 0.95-0.96). Subjects who had forward head posture were received deep cervical flexors strengthening using pressure biofeedback, 2 sets of 10 repetitions, followed by 2 mins of rest; 5 days per week for 4 weeks.

INTERVENTION

DEEP CERVICAL FLEXORS STRENGTHENING USING PRESSURE BIOFEEDBACK

The exercise procedure with pressure biofeedback (craniocervical flexor exercise) was explained to the subjects. Low load endurance exercises was used to increase the tonic holding capacity of deep neck flexors muscles. In this, subjects were positioned in supine lying. Then pressure biofeedback (Chattanooga 9210E) was placed between the plinth and the posterior aspect of the cervical spine just below the craniocervical junction. The subject's head and neck was positioned to ensure a neutral cervical spine and craniocervical position. The pressure sensor was inflated to 20 mm of Hg so that the space can be filled between the back of the neck and the plinth. As already instructed, subject placed the tongue on the roof of the mouth, lip together but teeth just apart, then asked the subject to posterior retraction of chin to push neck directly back on the sensor. Each subject was given sufficient time to practice the same exercise with pressure biofeedback unit. The dial was kept in front of the subject so that he can monitor any deflection of the pointer during holding phase which was 10 second. The feedback which was given by the pressure sensor showed the subject's ability to hold the position in a controlled manner. Each subjects perform the neck Cranio Cervical Flexion (CCF) movement at 5 different pressure levels (22, 24, 26, 28 and 30 mmHg) with 10 seconds hold at each level and 30 seconds rest between each level. The testing procedure was terminated if subject could not hold 10 seconds at specific pressure level. The maximum pressure level achieved (activation score) with 10 seconds hold was recorded for further strengthening protocol. **Dosages:** 2 sets of 10 repetitions, followed by 2 min of rest; 5 days per week for 4 weeks.

OUTCOME MEASURES

Assessment of forward head posture (measurement of craniovertebral angle) using MB ruler software

Subjects were assessed for any deviation of head posture using valid & reliable computerized photogrammetry with emphasis on craniocervical seg-

FIGURE A. Deep cervical flexors strengthening using pressure biofeedback

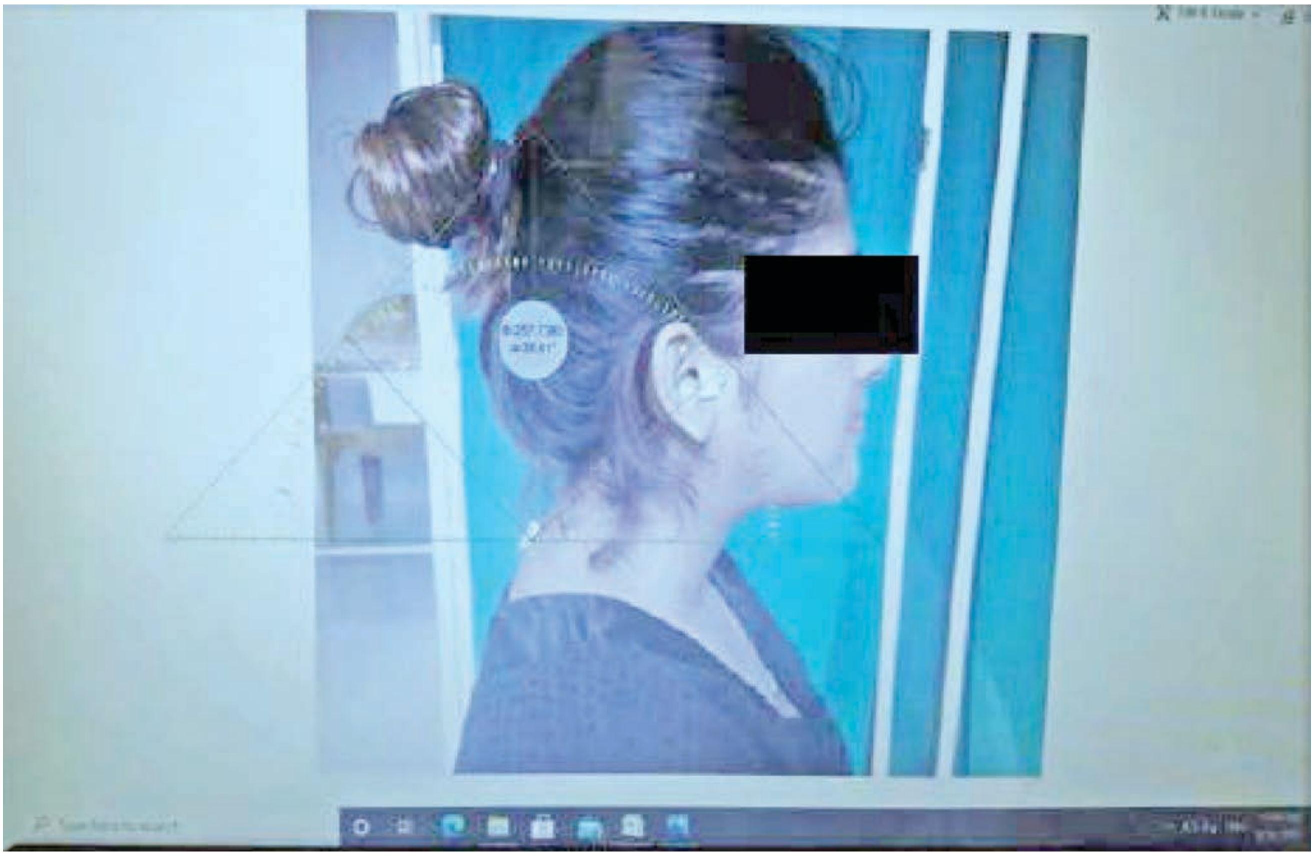

FIGURE B. Assessment of CVA

ment. The photographic records were obtained from a digital camera, positioned 3.5 cm from the subject, allowing the recording of the face and upper trunk in the sagittal plane (left or right view). The subjects were sitting over stool and looking forward in a relaxed posture. Skin over the anatomical landmarks was wiped with cotton soaked in spirit to remove skin secretions for proper fixation of adhesive markers. Adhesive markers were fixed over the anatomical landmarks. Anatomical landmarks are: spinous process of C7, tragus of the left or right ears. The photographs were analyzed using MB Ruler software - The craniovertebral angle (CVA), that is the angle between the horizontal line passing through C7 and a line extending from the tragus of the ear to C7 was obtained (Figure A). The literature reports high reliability of this procedure (ICC = 0.88). Then the photographs were transferred to laptop for measuring the craniovertebral angle by using MB ruler software. A pre–post measurement were taken. Selected participants vertical mandibular opening was measured using a millimeter ruler (ICC= 0.95-0.96).

Assessment of vertical mandibular opening

Subjects were asked to sit comfortably on back supported armless chair with feet flat on floor, hips and knees positioned at 90° angle and hands on their lap. The subjects were asked to focus on a point directly in front of them and to open their mouth as widely as possible without feeling any strain. The vertical mandibular opening was measured between the incisors edges of the right upper and lower central incisors teeth by using a millimeter ruler (ICC=

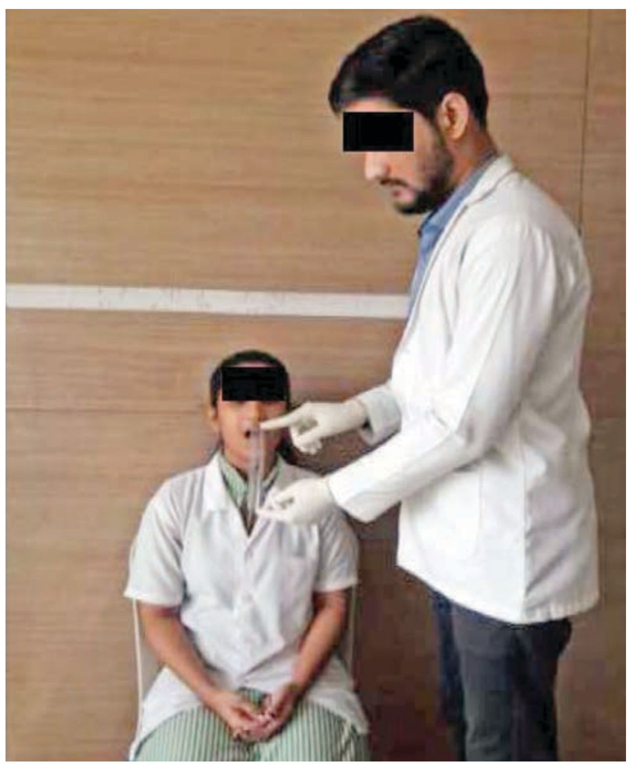

FIGURE C. Assessment of VMO

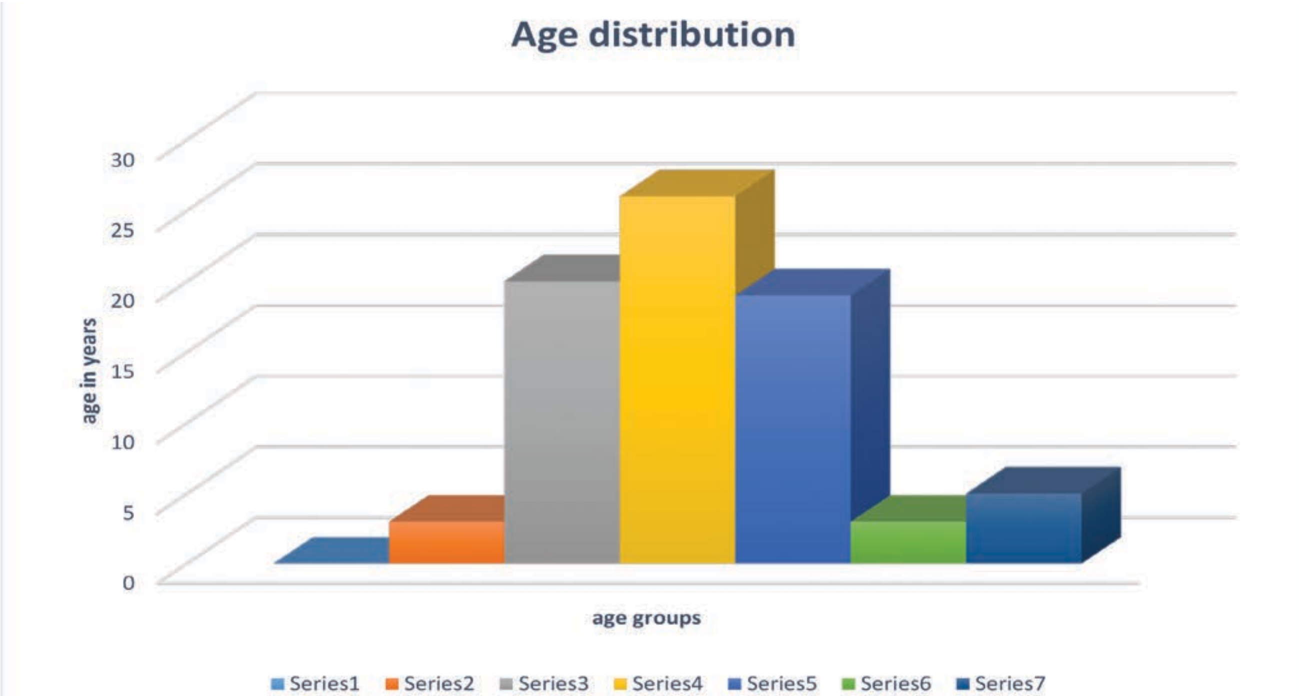

FIGURE 1. The age wise distribution of study subjects

Comments – The graph shows age wise distribution of study subjects.

0.95-0.96). The same procedure was repeated for three times and mean value of the readings will be obtained. A pair of sterile hand gloves were worn throughout the procedure.

RESULTS

The entire data of the study was entered and cleaned in MS Excel before it was statistically analyzed in "GraphPad Instat version 3.05". All the results are shown in tabular as well as graphical format to visualize the statistically significant difference more

TABLE 1. The age wise distribution of study subjects

Age in years	No of subjects (n=76)
18-19	3
20-21	20
22-23	26
24-25	19
26-27	3
28-30	5

FIGURE 2. The gender distribution of study subjects

Comments – The graph shows gender distribution of study subjects. There were 39 males & 37 females in the study

TABLE 2. The gender distribution of study subjects

Gender	Total subjects (n=76)
Male	39
Female	37

clearly. The data on qualitative characteristics was presented as n (% of cases). The data on quantitative characteristics was presented as mean ± standard deviation (SD) across study group. The statistical significance of difference of pre-treatment and post- treatment quantitative characteristics in study group (intra-group comparisons) was tested using paired 't' test, after confirming the underlying normality assumption of pre and post-treatment difference of parameters. The statistical significance of correlation between craniovertebral angle and vertical mandibular opening of study group carried out using Pearson's correlation coefficient test. The p-values less than 0.05 are considered to be statistically significant. All the hypothesis was formulated using two tailed alternatives against each null hypothesis (hypothesis of no difference). The entire data was analyzed statistically using "GraphPad Instat version 3.05" for MS Windows.

DISCUSSION

Total 84 subjects were included in the study. There were 8 dropouts. Out of 76 subjects there were 37 females and 39 males. For the comparison between pre- treatment craniovertebral angle & post-treatment craniovertebral angle within group "paired t test" was used. The results in the present study shows that strengthening of deep cervical flexors using pressure biofeedback was effective in improving craniovertebral angle (p value <0.0001). For the comparison between pre- treatment vertical mandibular opening & post-treatment vertical mandibular opening within group "paired t test" was used. The results in the present study shows that strengthening of deep cervical flexors using pressure biofeedback was effective in improving vertical mandibular opening (p value <0.0001). For the correlation between vertical mandibular opening & craniovertebral angle Pearson's correlation coefficient test was used. The results in the present study shows that there is moderate positive correlation (r=0.4509) exist between craniovertebral angle & vertical mandibular opening (p value <0.0001).

FHP results in increased external flexion torque to the vertebrae of cervical spine causing severe tension on the extensors of the neck and surrounding connective tissues [22]. FHP decreased the EMG activities of the middle trapezius, splenii, and sternocledomastoid muscle and these reduced activities resulted from changes in muscle length due to FHP and were associated with a decreased ability to generate force. Deep cervical flexor (DCF) has a major postural function in supporting and straightening the cervical lordosis. It has been found that certain muscles in the cervical spine tend to weaken, the most common of these being the DCF [23].

Outcome measures in the study group showed following results:

Effect of strengthening of deep cervical flexors using pressure biofeedback on craniovertebral angle: On comparing score with "paired t test", the p value obtained was <0.0001 which implies that it is extremely statistically significant (Table 3). This suggest that strengthening of deep cervical flexors using pressure biofeedback had an effect in improving craniovertebral angle after 4 weeks of treatment.

TABLE 3. Comparison of mean between pre - treatment & post-treatment for Craniovertebral angle (CVA)

CVA	Mean + SD	t value	p value	Significance
Pre-treatment	42.88±3.71	20.04	<0.0001	Extremely significant
Post-treatment	46.04±3.70			

**Values are mean ± standard deviation. P-values are obtained using paired t-test, after confirming the underlying normality assumption. P-value<0.05 is considered to be statistically significant*

The result found in our study is accordance with study done by Thavatchai Suvarnnato & Rungthip Puntumetakul (2020) on, Effect of specific deep cervical muscle exercises on functional disability, pain intensity, craniovertebral angle, and neck-muscle strength in chronic mechanical neck pain concluded that 6 weeks of training in both exercise groups can improve neck disability, pain intensity, CV angle, and neck-muscle strength in chronic mechanical neck pain. The current study showed that deep cervical flexor-muscle exercise significantly reduced pain intensity immediately at the conclusion of 4 weeks of training cervical flexor training enhanced the ability and improved neuromuscular control of deep cervical flexor muscles, including the longus colli and longus capitis [26-30].

FHP increases lordosis o-f the lower cervical spine, causing an increased extension of the middle cervical spine and flexion of the lower cervical spine, resulting in cervical muscle imbalance. In a previous EMG study, the concept of craniocervical flexor-exercise training was to focus more specifically on motor control and to train coordination between superficial and deep layers of cervical muscles. The focus on the longus colli and longus capitis muscles is to control head movement and stabilize the cervical spine. For these, craniocervical flexor-exercise training may eventually alter lordosis of the cervical spine, leading to improved FHP in individuals with neck pain. The results of the current study may confirm that craniocervical flexor training is essential for improvement of the CV angle [31].

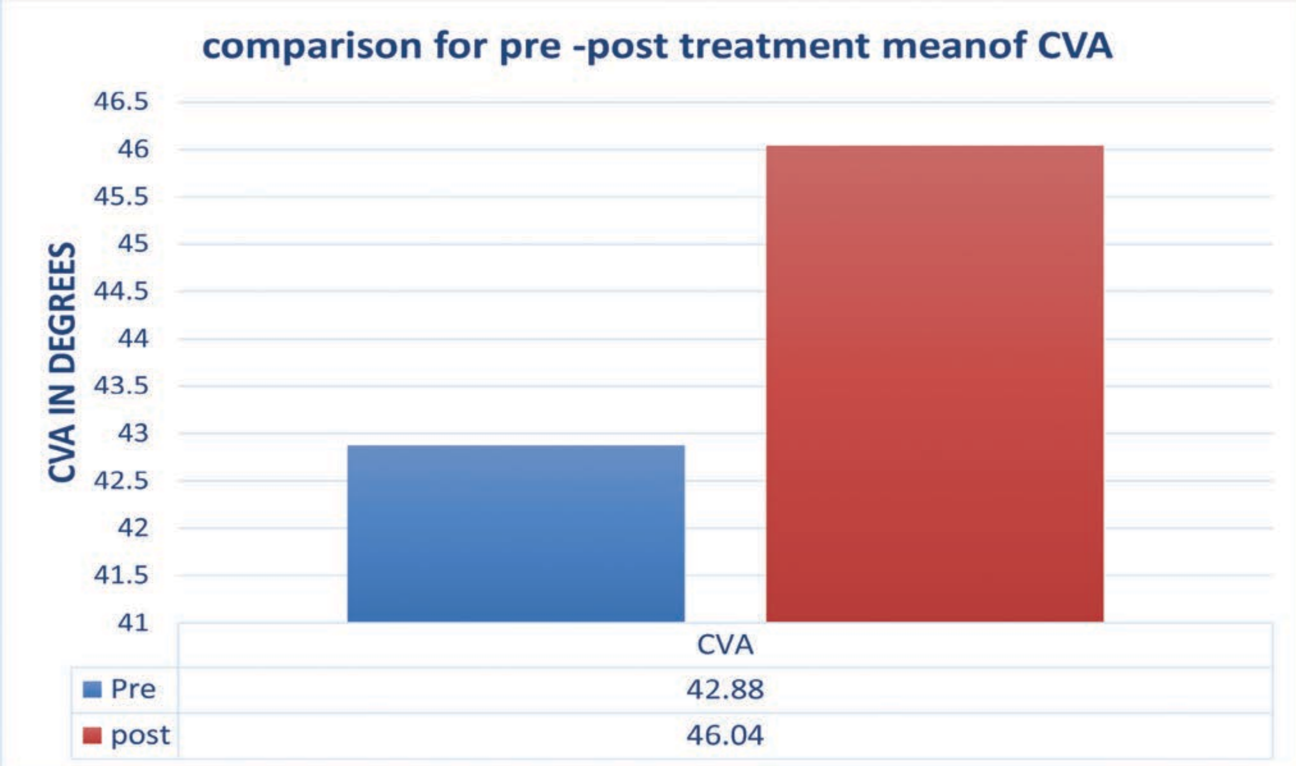

FIGURE 3. Comparison of mean between pre - treatment & post-treatment for craniovertebral angle (CVA)

Comments (Intra-Group comparison):

a. The average post-treatment craniovertebral angle was significantly improved in study subjects.

b. P value is <0.0001. This implies that deep cervical flexors training using biofeedback was extremely significant to improve craniovertebral angle.

Effect of strengthening of deep cervical flexors using pressure biofeedback on vertical mandibular opening: On comparing score with paired t test, the p value obtained was <0.0001 which implies that it is extremely statistically significant (Table 4). This suggest that strengthening of deep cervical flexors using pressure biofeedback had an effect in improving vertical mandibular opening after 4 weeks of treatment.

TABLE 4. Comparison of mean between pre - treatment and post-treatment for vertical mandibular opening

VMO	Mean + SD	t value	p value	Significance
Pre-treatment	3.24 ± 0.36	13.83	<0.0001	Extremely significant
Post-treatment	3.46 ± 0.33			

**Values are mean ± standard deviation. P-values are obtained using paired t-test, after confirming the underlying normality assumption. P-value<0.05 is considered to be statistically significant*

The result of our study in accordance with study done by Raja Laxmi V & Yuvarani Gopinath (2015) on effect of deep cervical flexor strengthening on vertical mandibular opening on subjects with forward head posture concluded that the strengthening of deep cervical neck flexor muscle has an effect on vertical mandibular opening. The study proved that there was an increase in vertical mandibular opening after correction of a forward head posture. Forward head posture leads to excessive lengthening with associated weakness of anterior vertebral neck flexors and tightness of neck extensor. Additional changes include shortening of suboccipital and suprahyoid musculature and lengthening of infrahyoid muscle with elevation of hyoid bone. There is also isometrical shortening of posterior cervical muscles while anterior submandibular muscles are stretched to cause retrusive force on mandibular in erect head posture. The initial condyle rotation occurs as mandibular elevators masseter, temporal and pterygoid muscles gradually relax and allowing gravity to depress the mandible [32].

Correlation between craniovertebral angle & vertical mandibular opening: Pearson's correlation coefficient test used where r value was 0.4509 & p value obtained was <0.0001 which implies that there is moderate positive correlation exist between craniovertebral angle & vertical mandibular opening (Table 5). This suggest that as craniovertebral angle increases/decreases, vertical mandibular opening also increases/decreases.

The result of our study in accordance with Roy La Touche, w z Alba Parı´s-Alemany (2011) which concluded that the experimental induction of different cranio-cervical postures influences the mandibular mouth opening value of the temporomandibular joint and muscles of mastication. There is a signifi-

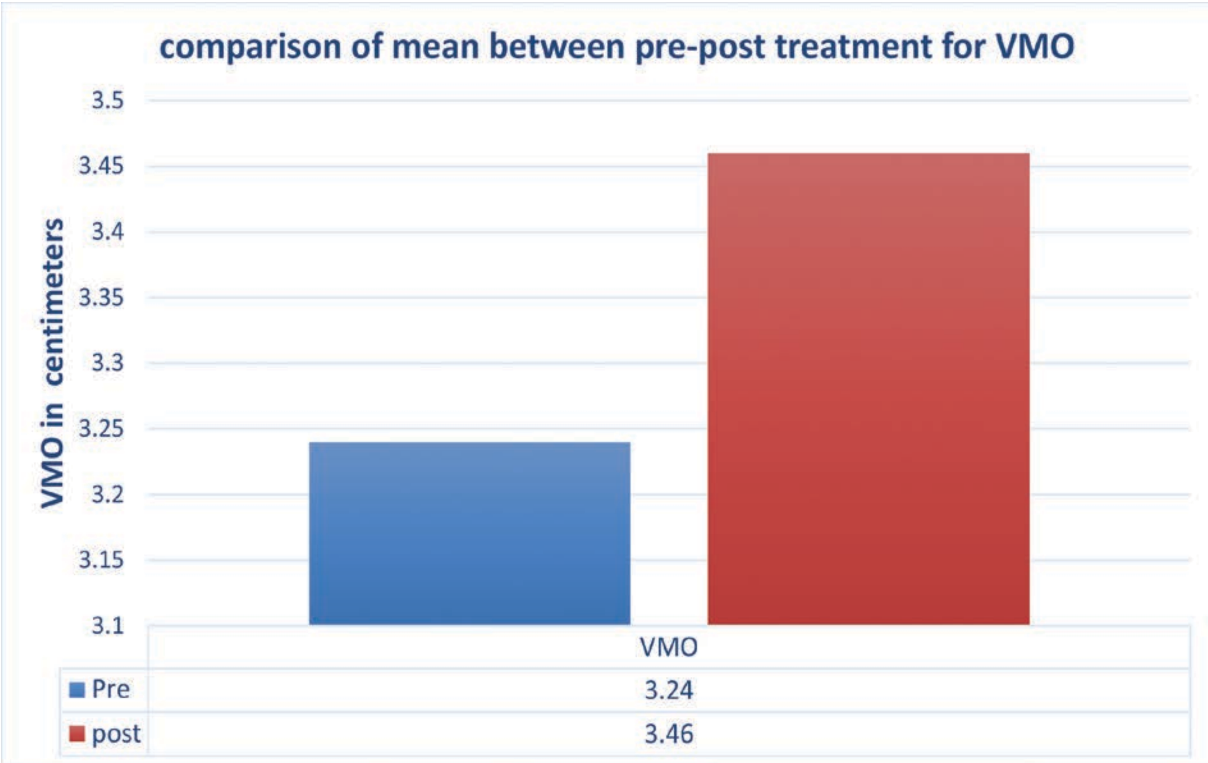

FIGURE 4. Comparison of mean between pre - treatment & post-treatment for vertical mandibular opening

Comments (Intra-Group comparison):

a.The average post-treatment vertical mandibular opening was significantly improved in study subjects.

b P value is <0.0001. This implies that deep cervical flexors training using biofeedback was extremely significant to improve vertical mandibular opening.

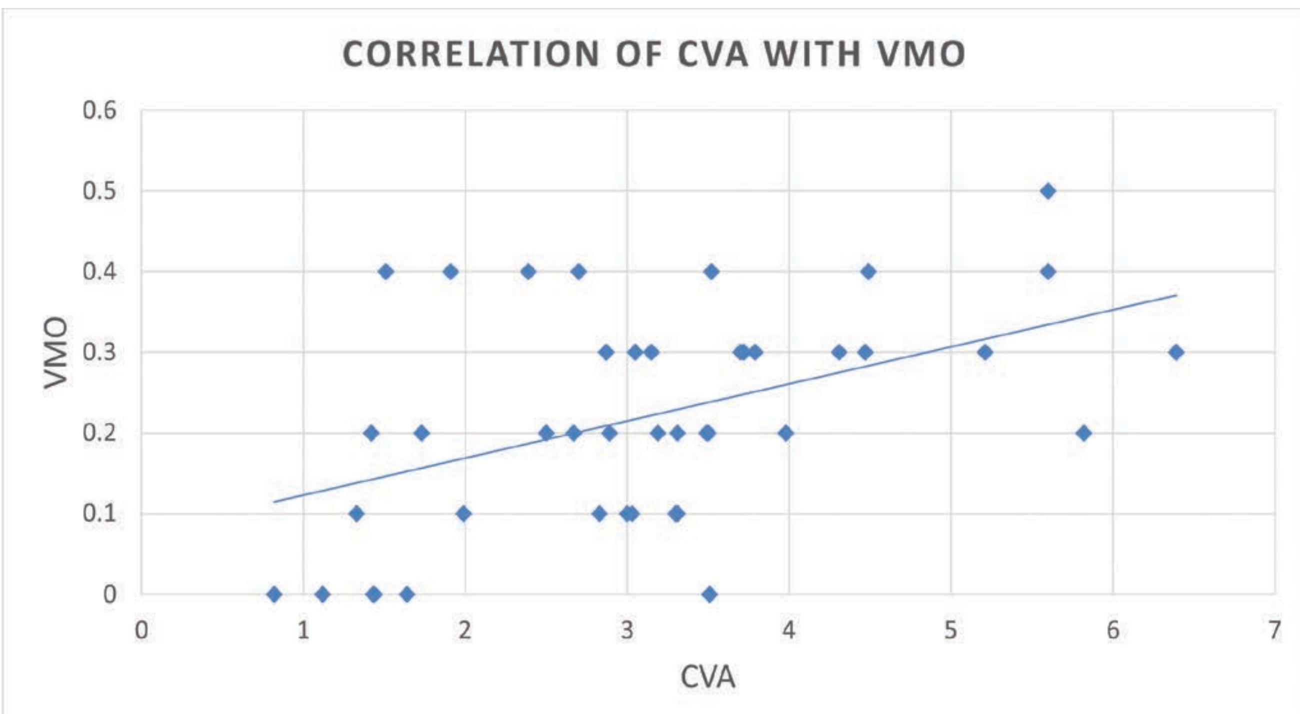

FIGURE 5. Correlation of craniovertebral angle (CVA) with vertical mandibular opening (VMO)

Comments (Intra-Group comparison):

a. There were moderate positive correlation (r=0.4509) found between craniovertebral angle & vertical mandibular opening.

b. This means that as craniovertebral angle increases/decrease, vertical mandibular opening also increases/decreases.

TABLE 5. Correlation of craniovertebral angle (CVA) with vertical mandibular opening

CVA	VMO	Pearson correlation coefficient (r value)	p value
3.16 ± 1.37	0.22 ± 0.14	0.4509	<0.0001

**Values are mean ± standard deviation. P-value and 'r' – correlation coefficient are obtained using Pearson's correlation coefficient test, after confirming the underlying normality assumption. P-value<0.05 is considered to be statistically significant*

cant relationship between forward head posture and trempromandibular disorders. The cervical muscle activity influnces the masticatory muscle activity. Forward head posture produces a greater muscle activity in the temporal and masseter muscles .The muscle activity resulting from craniocervical extension of the head produces an elevation and retrusion force that act on the mandible which results in decrease in free-way space of TMJ. The effect of this abnormal position may lead to an excessive amount of tension in the muscles of mastication & the supporting structures [33-37].

Our study results also justify by Kapandji, states that in extension or backward bending of the cranium, the occipital condyles slide anteriorly on the lateral masses of the atlas (C-1). When a convex joint surface moves on a concave surface, the rotary movement or roll and the translatory movement or slide occur in opposite directions simultaneously. When the occiput bends backward, the convex occipital condyles simultaneously slide anteriorly on the concave atlas, and vice versa [38-40].

CONCLUSION

The study concluded that strengthening of deep cervical flexors using pressure biofeedback was effective in improving craniovertebral angle & vertical mandibular opening. Also study concludes that there was positive correlation exists between craniovertebral angle & vertical mandibular opening.

Conflict of interest:
I undersign, certificate that I do not have any financial or personal relationships that might bias the content of this work

Author's contributions:
The authors confirm contribution to the paper as follows: study conception and design: Dr.Mukesh shinde & Dr.Mahesh Mitra; data collection: Dr.Mukesh shinde. Author; analysis and interpretation of results: Dr.Mukesh shinde & Dr.Pradnya Mahajan; draft manuscript preparation: Dr.Mukesh shinde. All authors reviewed the results and approved the final version of the manuscript.

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