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Effect of mini stability ball exercises versus pressure biofeedback unit training on pain, endurance and disability in chronic non-specific neck pain

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ABSTRACT

Background

Mini stability ball exercises and Pressure biofeedback unit exercises are effective in core muscles training with added advantage. There is a dearth of evidence in studies whether mini stability ball exercises are effective for reducing pain, endurance and disability in non-specific neck pain and comparison of mini stability ball exercises and pressure biofeedback training for non-specific neck pain. Hence the current study has been undertaken.

Aim

To compare the effect of mini stability ball exercises vs pressure biofeedback unit training on pain, endurance and disability in chronic non-specific neck pain.

Method

58 participants in between age group of 25 to 55 years with non-specific neck pain were randomly divided into 2 groups of 29 each. The study was carried over a period of 6 weeks, the participants Group A received mini stability ball exercises in addition to conventional physiotherapy treatment and Group B received pressure biofeedback unit training in addition to conventional physiotherapy treatment. Participants were assessed for pain, endurance and disability at baseline, end of 3rd week and 6th week of the study using the outcome measures Numeric pain rating scale (NPRS), Craniocervical flexion test (CCFT) and Neck disability Index (NDI).

Results and Conclusion

The participants who received pressure-biofeedback unit training with conventional treatment their NPRS, CCFT score and NDI score improved more significantly ($p<0.0001$) as compared to those who received mini stability ball exercises with conventional treatment.

Abbreviations

NPRS- Numeric pain rating scale, NDI- Neck disability index, PBU- Pressure biofeedback unit, CCFT- Cranio-cervical flexion test, DCF- Deep cervical flexors, SCM- Sternocleidomastoid

Keywords: Mini stability ball exercises, Pressure biofeedback unit, Endurance, Non- specific neck pain

INTRODUCTION

Neck pain is one of the prevalent musculoskeletal disorders with an annual incidence of 30 % to 50% in the workforce and general population. [1] The patho-anatomical cause of an individual's pain cannot be identified in most cases and is therefore considered non-specific, characterized primarily as non-articular and non-systemic in nature. [2] Non-specific neck pain is characterized as pain with or without radiation without the diagnosis of a particular systemic disease as the underlying cause of the symptoms, it has a mechanical or postural basis. [3] Cervical spine function is directly influenced by cervical flexor endurance. Any compromise to cervical spine flexor endurance activity could lead to cervical related dysfunction, tissue strains, predisposition to injury chances & pain. [4, 5, 6]

Long periods of static posture and repetitive neck movement lead to isometric muscle contractions with buildup of lactic acid, compression of the blood vessels that can lead to temporary ischemia. Continuous low intensity contraction of neck and shoulder muscles has been shown to induce Ca2+ accumulation and homeostatic disturbances in the active muscles due to poor blood circulation and an impaired mechanism for removing metabolic wastes. Due to the lack of oxygenation and nutrients, these pathological changes in the active muscles lead to microlesions, overuse of injury and pain. Hence reducing endurance of neck muscles. [7] Szeto et al. documented deficits in the postural capacity of DCF (Deep Cervical Flexor) muscles along with impaired activation in people with neck pain.[8] In particular, deep cervical flexors that support the neck, become weakened, delayed contraction occurs and in effect contribute to neck pain. [9] The CCFT (Craniocervical Flexor Training) regime seems to be an ideal strategy for specific activation of DCFs (deep cervical flexors) and reduction of increased SCM (Sternocleidomastoid) muscle activity. There is evidence that restoration of the supporting capacity of deep cervical flexors parallels reduction in neck pain. [10]

Mini stability ball is used in core muscle exercise program. Mini stability ball works to the hardest providing a good progressive workout for long-term training. The smaller diameter of the ball, allows for greater range of motion during the exercise, increasing muscle use and work therefore endurance. As seen in previous research mini stability ball had a significant advantage in working the muscles harder and at a better range of motion on lumbar spine. [11, 12] Deep cervical flexor muscle training with pressure biofeedback is a method for retraining the important neck-stabilizing postural muscles, which may lead to improvements in neck pain. Movement or change in position causes volume changes in the pressure bag, which is registered by the PBU (Pressure biofeedback unit) device. PBUs provide the user with feedback regarding specific muscular contractions. [13, 14, 15]

The training concept proposed in this study represents a new approach to investigate the effectiveness of mini stability ball exercises in chronic non-specific neck patients. To our knowledge, no previous studies have compared mini stability ball exercises with pressure biofeedback unit on chronic non-specific neck pain patients. Hence the purpose of the present study was to see the effectiveness of mini stability ball exercise versus pressure biofeedback unit training on pain, endurance of deep neck flexors and disability on chronic non-specific neck pain.

METHODOLOGY

Participants were selected on the following criteria: (1) Participants with non-specific neck pain between age group of 25-55 years (2) Chronic non-specific neck pain i.e. since 3 months or more. (3) Literate individuals who know to read Marathi. (4) Neck pain score on the numeric pain rating scale (NPRS) in the range group of 3-7. (5) Neck disability index (NDI) score- mild to moderate (5-24). (6) CCFT- minimum baseline pressure of 20 mm Hg for 10 secs hold.

Participants with history of recent neck or shoulder injuries, neck pain secondary to other conditions (neoplasm, neurological diseases or vascular diseases), Cervical radiculopathy presenting neurological deficits, Infection or inflammatory arthritis in the cervical spine, Poor general health status that would interfere with the exercises during the study, Spinal curve changes were excluded from the study.

PROCEDURE

The study procedure was conducted at Bhausaheb Sardesai Talegaon Rural Hospital (Physiotherapy O.P.D and I.P.D) .Consent of the ethical committee and Head of the institution was obtained prior to commencing the study. 113 subjects were screened. 75 participants met this criteria, 17 subjects dropped out of the study,9 subjects out of Group A and 5 subjects out of Group B, 3 subjects dropped out of the study after 3 weeks of intervention from Group B. Informed consent was taken from them in written format. The procedure was explained to the participants by the therapist. Special tests were performed like Spurling's test, ULTT, distraction test and adson's test for exclusion criteria. 58 participants were randomly divided into two groups with the help of chit method with replacement. Group A consisted of 29 participants and Group B consisted of 29 participants.

Participants were assessed for pain, endurance and disability at baseline, end of 3rd week and 6th week of the study using the outcome measures. Baseline, end of 3rd week and 6th week outcome measures were taken by a blinded evaluator.

Mini stability ball exercises treatment method (group A)

Individuals selected for the group were given mini stability ball exercises with conventional treatment for non-specific neck pain. Participants lied on a plinth in supine crook lying position. Appropriate thickness of folded towel was placed under the head to maintain the neutral position, if required. The edge of towel was aligned with the base of occiput and the upper cervical region was free, it was observed that a ball of 4 inches keeps the neck in neutral position. Hence. mini stability ball (size 4 inches) was placed underneath the participant's neck, then they performed chin tuck (nodding movement) and were asked to hold the position. The exercises were given for 3 sessions per week for 6 weeks, a total of 18 sessions. Duration of exercise program was 3 sets, 10 repetitions with 10 secs hold for each repetition; 2 mins rest was given between the sets. [16]

Pressure biofeedback unit training method (group B)

Individuals selected for the group were given pressure biofeedback unit training with conventional treatment for non-specific neck pain. Training of cranio-cervical flexors followed the protocol described by **Jull et al.** [10] Subjects were positioned on a plinth in crook supine lying position. Appropriate thickness of folded towel was placed under the head to maintain the neutral position, if required. PBU air bag (PBU- Stabilizer TM, Chattanooga Group, INC., Chattanooga, TN) was clipped together in three-fold, fastened and was placed suboccipitally. The deflated pressure sensor was kept behind the neck just next to the occiput and was inflated up to a baseline pressure of 20mm Hg after inserting it behind the neck to just fill the space between the back of neck and supporting surface without pushing the neck into a lordosis. Subjects were instructed to perform craniocervical flexion and practice head nodding action to progressively target (reach the incremental targets) and hold the 5 pressure levels for 10s between 22 and 30mmHg. Minimum requirement for satisfactory performance was 26 mmHg while 28 and 30 mmHg are targets for ideal performance. Duration of exercise program was 3 sets, 10 repetitions each set, 6 weeks, 3 days a week; 2 mins rest was given between the sets. [8, 9, 10, 14, 17]

Conventional exercise protocol common to both groups

- Hot pack was given over the painful neck region
- IFT was given over neck region; 80- 120 Hz; Quadripolar method
- Cervical range of motion exercises include flexion, extension, side flexion, and rotation
- Postural reeducation programme
- Stretching of tight muscles of neck and scapula
- Scapular stabilization exercises

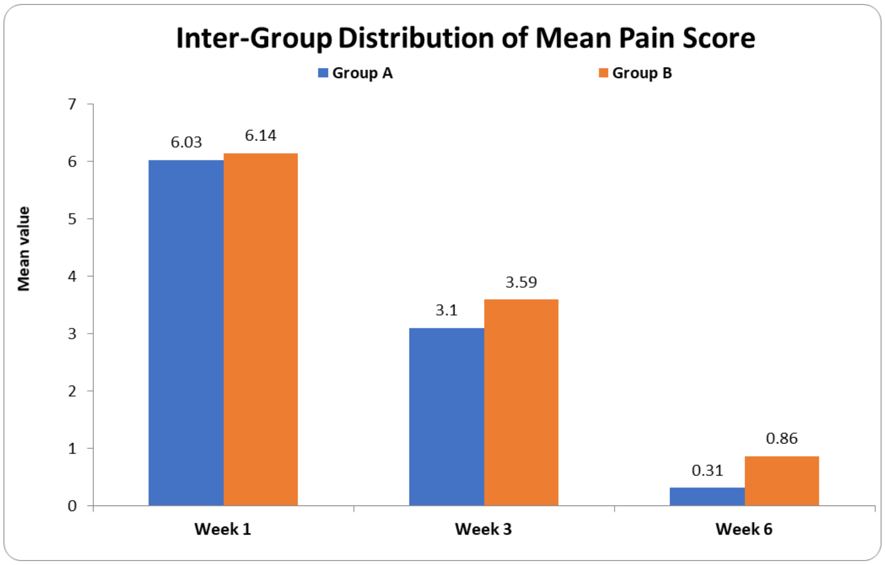
RESULTS

Table 1) Inter-group and intra-group comparison of mean pain score (NRS)

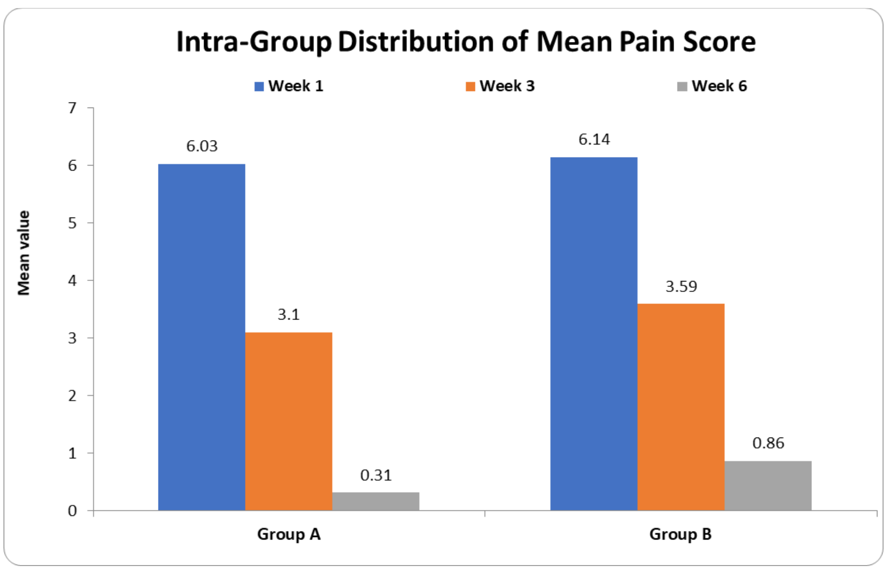
Pain Score (NRS)	Group A (n=29)		Group B (n=29)		P-value
	Mean	SD	Mean	SD	
Week 1	6.03	0.94	6.14	0.87	0.667^{NS}
Week 3	3.10	1.17	3.59	1.24	0.134^{NS}
Week 6	0.31	0.47	0.86	0.79	0.002**
% Change at Week 6	95.24%	--	86.04%	--	0.001***

P-value (Intra-group)		
Week 1 v Week 3	0.001^{***}	0.001^{***}
Week 1 v Week 6	0.001^{***}	0.001^{***}
Week 3 v Week 6	0.001^{***}	0.001^{***}

Values are mean and SD. P-value (Inter-Group) by independent sample t test. P-value (Intra-Group) by repeated measures analysis of variance (RMANOVA). P-value<0.05 is considered to be statistically significant. **P-value<0.01, ***P-value<0.001, NS-Statistically non-significant.



Graph 1.) Inter-group distribution of mean Pain score



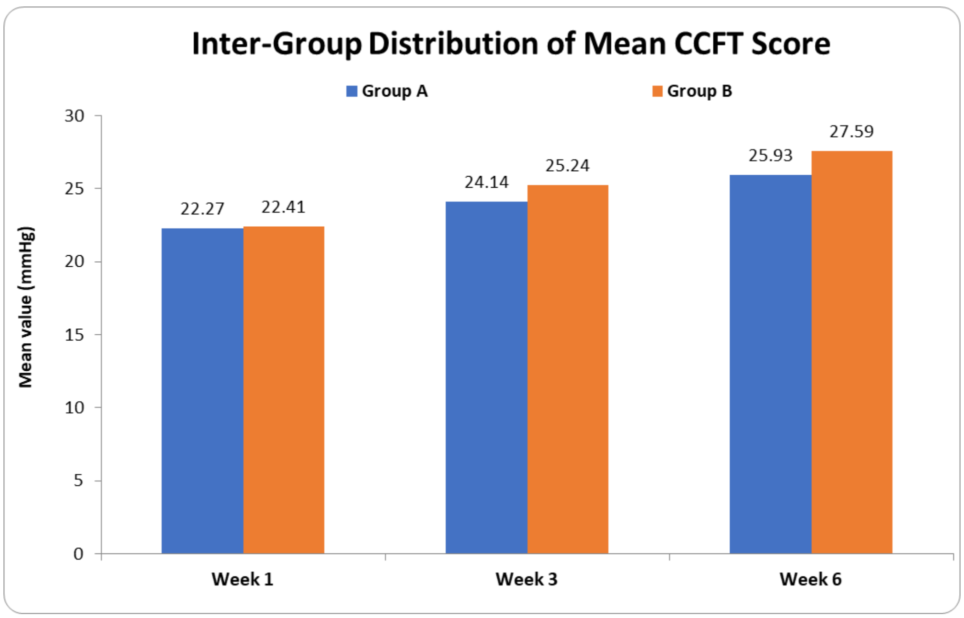
Graph 2.) Intra-group distribution of mean Pain score

Table 2) Inter-group and intra-group comparison of mean CCFT score (Activation Score)

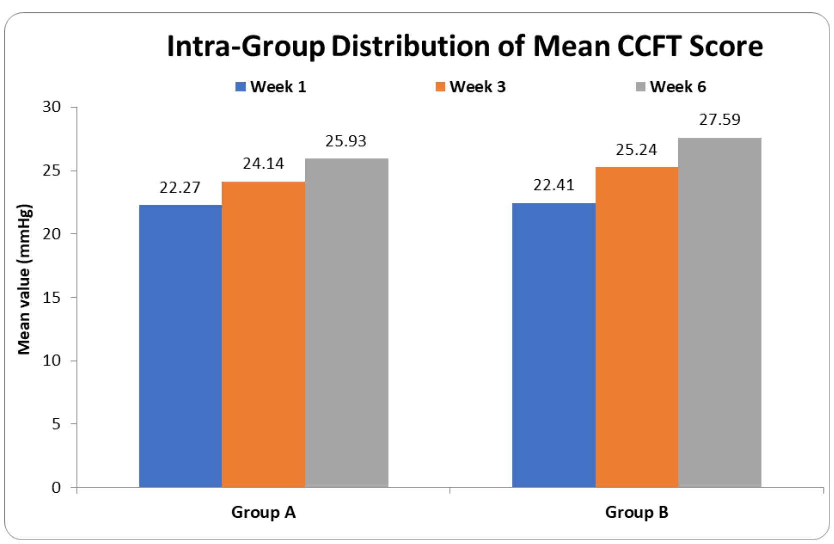
CCFT score (mmHg)	**Group A (n=29)**		**Group B (n=29)**		**P-value**
	Mean	**SD**	**Mean**	**SD**	
Week 1	22.27	0.70	22.41	0.82	0.496^{NS}
Week 3	24.14	1.06	25.24	1.24	0.001^{***}

Week 6	25.93	1.36	27.59	1.35	0.001***
% Change at Week 6	16.46%	--	23.17%	--	0.001***
P-value (Intra-group)					
Week 1 v Week 3	0.001***		0.001***		
Week 1 v Week 6	0.001***		0.001***		
Week 3 v Week 6	0.001***		0.001***		

Values are mean and SD. P-value (Inter-Group) by independent sample t test. P-value (Intra-Group) by repeated measures analysis of variance (RMANOVA). P-value<0.05 is considered to be statistically significant. **P-value<0.01, ***P-value<0.001, NS-Statistically non-significant.



Graph 3.) Inter-group distribution of mean CCFT score (activation score)

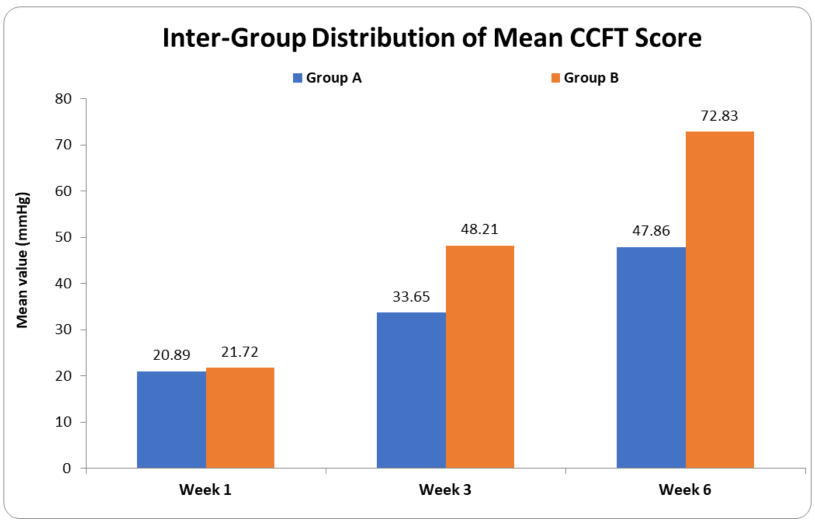


Graph 4.) Intra-group distribution of mean CCFT score (activation score)

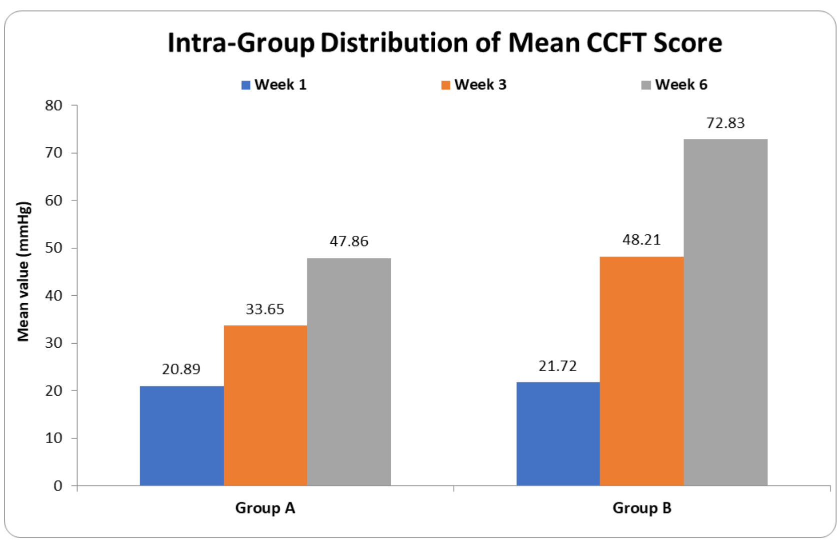
Table 3) Inter-group and intra-group comparison of mean CCFT score (Performance index)

CCFT score (mmHg)	Group A (n=29)		Group B (n=29)		P-value
	Mean	**SD**	**Mean**	**SD**	
Week 1	20.89	7.22	21.72	5.47	0.625[NS]
Week 3	33.65	9.02	48.21	10.67	0.001***
Week 6	47.86	10.13	72.83	12.69	0.001***
% Change at Week 6	145.34%	--	247.14%	--	0.001***
P-value (Intra-group)					
Week 1 v Week 3	0.001***		0.001***		
Week 1 v Week 6	0.001***		0.001***		
Week 3 v Week 6	0.001***		0.001***		

Values are mean and SD. P-value (Inter-Group) by independent sample t test. P-value (Intra-Group) by repeated measures analysis of variance (RMANOVA). P-value<0.05 is considered to be statistically significant. **P-value<0.01, ***P-value<0.001, NS-Statistically non-significant.



Graph 5.) Inter-group distribution of mean CCFT score (Performance Index)

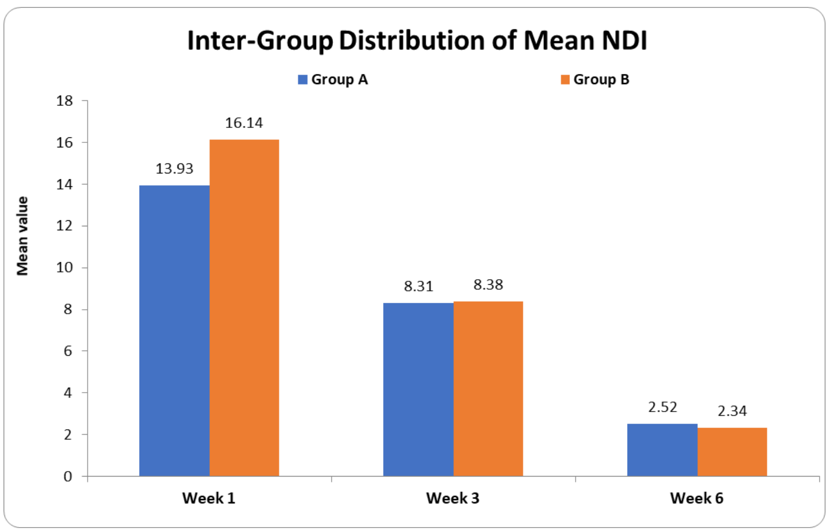


Graph 6.) Intra-group distribution of mean CCFT score. (Performance Index)

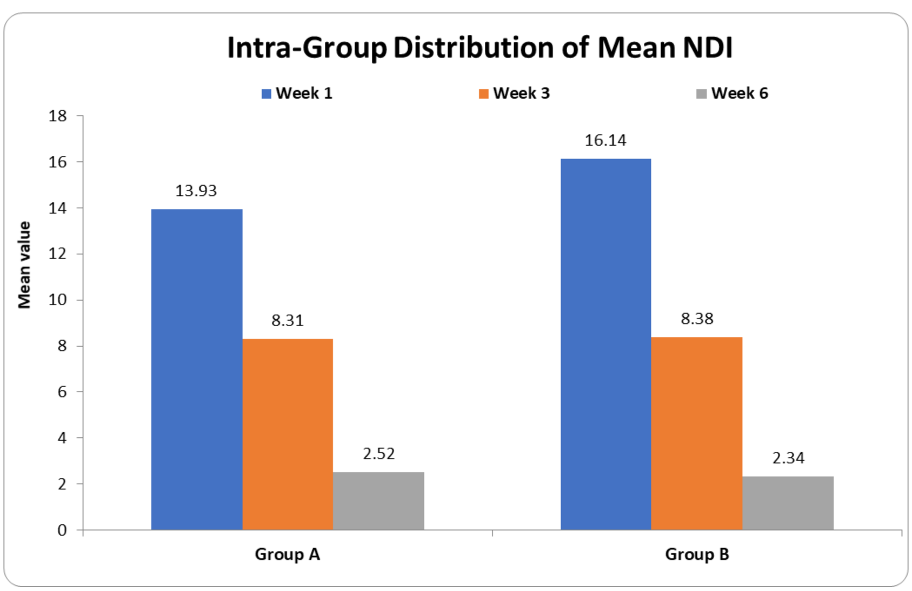
Table 4) Inter-group and intra-group comparison of mean neck disability index (NDI)

NDI	Group A (n=29)		Group B (n=29)		P-value
	Mean	**SD**	**Mean**	**SD**	
Week 1	13.93	3.83	16.14	4.51	0.051^{NS}
Week 3	8.31	2.83	8.38	3.16	0.930^{NS}
Week 6	2.52	2.51	2.34	1.29	0.744^{NS}
% Change at Week 6	83.67%	--	85.33%	--	0.591^{NS}
P-value (Intra-group)					
Week 1 v Week 3	0.001***		0.001***		
Week 1 v Week 6	0.001***		0.001***		
Week 3 v Week 6	0.001***		0.001***		

Values are mean and SD. P-value (Inter-Group) by independent sample t test. P-value (Intra-Group) by repeated measures analysis of variance (RMANOVA). P-value<0.05 is considered to be statistically significant. **P-value<0.01, ***P-value<0.001, NS-Statistically non-significant.



Graph 7). Inter-group distribution of mean NDI



Graph 8). Intra-group distribution of mean NDI

Result interpretation

- Intergroup comparison of pain score was significantly reduced in both the treatment groups, but Group B showed more reduction in pain compared to Group A after 6 weeks of treatment. NRS score in week 1 and week 3 scores among the subjects did not differ significantly between 2 groups. The week 6 mean pain score was significantly higher in Group B compared to group A.
- Intragroup comparison of pain in Group A and Group B showed significantly reduced NRS score in week 3 and week 6 compared to week 1 NRS score. The week 6 pain score was significantly lower compared to week 3 mean pain score.
- The intergroup comparison in the week 3 and week 6 mean CCFT score (activation score) was significantly higher in Group B compared to Group A. Week 1 CCFT score (performance index) did not show any significant difference between the two study groups. Week 3 and week 6 CCFT score (performance index) was significantly higher in Group B compared to Group A.
- The intragroup comparison in Group A and B, week 3 and week 6 CCFT score (activation score) was significantly higher compared to week 1 CCFT score. The week 6 mean CCFT score was significantly higher compared to week 3 mean CCFT score.
- In group A and B, Week 3 and week 6 CCFT score (performance index) was significantly higher compared to week 1 CCFT score. Week 6 CCFT score was significantly higher compared to week 3 CCFT score.
- The intergroup comparison of the NDI score of week 1, week 3 and week 6 did not show any significant difference between two study groups. The intragroup comparison in Group A and B, the NDI score of week 3 and week 6 was significantly lower compared to week 1 NDI score. Week 6 NDI score was significantly lower compared to week 3 NDI score. Our research found that NDI was decreased from 16.14 to 2.34 by pressure biofeedback unit training, and from 13.93 to 2.52 by mini stability ball exercises, both of which were statistically significant differences.

DISCUSSION

Physiological rationale

- Overall results of this study showed that both the groups i.e. Group A which consisted of mini stability ball exercise along with conventional treatment and Group B which included pressure biofeedback unit training with conventional treatment demonstrated significant reduction in pain intensity measured by NRS (Numeric pain rating scale) score, increased endurance of deep cervical flexors measured by CCFT (cranio-cervical flexion test) score and reduced functional disability, measured by NDI (Neck disability index) score. However, Group B improved to a greater extent in pain reduction, endurance and functionality improvement than Group A.
- Pain in the neck and disability are linked. The relationship between neck pain and disability is not straightforward as these are subjective measures and may therefore be influenced by factors such as physiology, psychosocial and environment. Since neck pain is one of the most common complaints seen in many people, tendency for recurrence and chronicity is partly attributable to persistent changes in cervical neuromuscular control that have been well documented in patients with neck pain, this in turn will result in reduced endurance of deep cervical neck flexors and may lead to further progression disability. Therefore, if neck pain increases, there is reduced endurance of deep cervical flexors which will result in disability on a long run.
- Because deep cervical flexors consist of mixed muscle fibers, neck pain may lead to the transformation of type I fibers into type IIB fibers, which suggests a loss of postural support capacity and segmental cervical muscle control. A similar process of muscle-fibre transformation has been demonstrated in laboratory-based research of patients with persistent cervical pain, with muscle biopsies showing these changes in two of the deep cervical muscles, i.e. the longus colli and longus capitis. Pain-induced neuromuscular adaptation results in inhibition, inability to selectively activate the deep cervical muscles and disruption of the deep cervical muscle feedforward mechanism. [18]
- Possible pain reduction mechanism may be attributed to increased endorphins following

training and better neuromuscular control, muscle contraction from exercise training stimulates mechanoreceptors, including muscle spindles, Golgi tendon organ, and joint proprioceptors. Signals from the receptors cause the release of endogenous opioids and stimulate the release of endorphins from the pituitary gland. Muscle contractions activate muscle ergoreceptors (stretch receptors). These secretions may cause both peripheral and central pain to be blocked. Neck exercises allow the musculotendinous proprioceptors to downgrade their stretch reflex responses using operant conditioning techniques and multiple practice sessions. The intrafusal fibers may be reset, discontinuing the cycle of muscle tension, impaired circulation with metabolite accumulation and pain associated with myogenic (myofascial) pain. [17]

- In accordance with this study Zaheen et al. pressure biofeedback provides extrinsic feedback which gives the patient knowledge of performance. A therapist provides the information through the apparatus and by attending to the information the patient forms a “closed loop”. Feedback helps in motor learning which is a set of processes associated with practice or experience leading to permanent changes in the capability of responding. Biofeedback techniques are used to augment the patient’s sensory feedback mechanisms through precise information about body processes that might otherwise be inaccessible. The basis for this approach is that repeated activation of the deep cervical flexor muscles may induce neuroplastic changes that in turn will lead to improved recruitment of the trained muscle during complex functional tasks. The increased activation of the deep cervical flexor muscles post training may reflect both central and peripheral adaptations. [8] Pressure biofeedback can be utilized during rehabilitation to give the patient visual real-time feedback to facilitate a neutral spine position during exercise.
- Other mechanisms, such as nociceptor sensitization due to intra-muscular shear forces are also considered to play a role in which the superficial muscles of the neck shoulder region, i.e., the sternocleidomastoid, anterior scalene and upper trapezius muscles, demonstrate increased activities compared to deeper postural stabilizers like the deep cervical flexors. [17] Therefore, using DCF training as a rehabilitation program for non-specific neck pain is based on the rationale that DCF plays a major role in the stabilization of the head and neck posture.
- In our study positive changes are attributed to the implementation of the mini stability ball training, it improves core stability, and portrays the complex interaction of passive (joint articulations and spinal ligaments) and active (neural and muscular) subsystems that maintain intervertebral neutral zones within the physiological limits (Panjabi, 1992). [19, 20] Research also suggests the adaptation gained from stability ball training is likely to result in better coordination of synergistic and stabilizer core muscles (Rutherford and Jones, 1986). [21] The muscles that make up the core can be divided into local and global groups based on location and attachment sites (Bergmark, 1989). [22]
- This concluded that, pressure biofeedback unit training is more effective than mini stability ball exercises on non-specific neck pain patients.

CONCLUSION

The present study concluded that

Both mini stability ball exercises and pressure biofeedback unit training were effective in neck pain patients. Pressure-biofeedback unit training was more effective than mini stability ball exercises on chronic non- specific neck pain patients, endurance and functional disability and hence it can be included in the rehabilitation of patients suffering from chronic non-specific neck pain for reducing pain, increasing endurance of DCF muscle and reducing functional disability.

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