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EFFECTS OF CERVICAL STABILIZATION EXERCISES ON NECK PROPRIOCEPTION IN PATIENTS WITH CERVICOGENIC HEADACHE

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ABSTRACT

Cervicogenic headache is gaining prevalence in young adults along with proprioception deficit in the cervical region. Methodology: In this study, 30 participants who met the diagnostic criteria for Cervicogenic headache were randomized into two groups: experimental group and control group. The control group was given stretching exercises. The experimental group in addition to stretching performed cervical stabilization exercises. The intervention was followed 3 times a week for 4 weeks. Prior to and after the programme, Headache disability index and neck proprioception were evaluated. Both the groups had significantly reducedHeadache disability index scores and neck proprioception error at the end of 4th week ($p<0.05$). Headache disability index scores and neck proprioception error improved more in the experimental group.Conclusion: Cervical stabilization exercises along with stretching are more effective in improving neck proprioception and Headache disability index than stretching alone.

KEYWORDS: **Cervicogenic headache, muscle spindle, neck proprioception, stabilization exercise, stretching.**

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INTRODUCTION

A headache arising from musculoskeletal disorders of the cervical spine is termed as Cervicogenic headache (CGH) (Sjaastad, Fredriksen and Pfaffenrath, 1990).Cervical headaches are estimated to affect approximately 2.5% of the adult population and account for 15-20% of all chronic and recurrent headaches (Nilsson, 1995).The World Cervicogenic Headache Society has defined Cervicogenic Headache as “referred pain perceived in any part of the head and caused by a primary nociceptive source in the musculoskeletal tissues that are innervated by the cervical nerves.” The actual source of pain originates not in the head but in the cervical spine joint complex. CGH arises primarily from musculoskeletal dysfunction in the upper three cervical segments. The pathway by which pain originating in the neck can be referred to the head is the trigeminocervical nucleus, which descends in the spinal cord to the level of C3/4, and is in anatomical and functional continuity with the dorsal gray columns of these spinal segments (Hall, Briffa and Hopper, 2008).

A number of reports of muscle tightness and trigger points associated with CGH have been reviewed by Hall, Briffa and Hopper (2008). Various muscles have been implicated, including upper trapezius, sternocleidomastoid, scalenes, levator scapulae, pectoralis major and minor, and short sub-occipital extensors (Treleaven, Jull and Atkinson, 1994; Jull, Barrett, Magee and Ho, 1999; McDonnell, Sahrmann and Van Dillen, 2005; Zito, Jull and Story, 2006). Altered neuro-motor function of the neck flexor synergy has been identified in the cervicogenic headache population (Watson and Trott, 1993; Jull, Barrett, Magee and Ho, 1999). The deep cervical flexor (DCF) group is composed of the longuscapitis, longuscolli, rectus capitis anterior, and lateralis. Neck flexor synergy refers to the ability to utilize the DCF to produce craniocervical flexion and maintain intersegmental stability for the midcervical muscles to act, primarily the sternocleidomastoid and scalenes (Janda, 1994). Sensorimotor disturbance has also been implicated in neck disorders. Clinical measures of sensorimotor disturbance include cervical joint position sense, postural stability, and occulomotor control (Treleaven, 2008). The receptors for proprioception in the neck include the muscle spindles that are present in high density in the intervertebral muscles and dorsal muscles (Loudon, Ruhl and Field, 1997). Proprioceptive inputs from the cervical musculature are important in head-eye co-ordination and postural orientation. Altering the afferent input from the upper cervical region can result in disturbances of gait, dizziness, loss of balance, ataxia, etc. (Kulkarni, Chandy and Babu, 2001). This altered neck flexor synergy and the sensory motor disturbance seen in and around the neck arises a need for a proprioceptively mediated rehabilitation programme. No study till date has investigated the combined effect of stabilization exercise and stretching for improving neck proprioception. The exercises directly addressed the muscle impairment found in CGH patients.

METHODS

Participants

30 female participants aged between 20-40 years, were recruited from outpatient department of Sardar Bhagwan Singh Post Graduate Institute of Biomedical Sciences and Research, Dehradun, India. Study was performed in accordance with ethical consideration of the institute and their consent was taken prior to study.They entered one of two groups, an experimental group (n=15, mean age 23.5±2.99 years) or a control group (n=15, mean age 22.9±2.38 years) and comparisons between the two groups were made. The inclusion criteria followed those documented by Sjaastad et al for CGH. Exclusion criteria specified bilateral headaches (tension type headache), features suggestive of migraine and chronic respiratory disease. Those who fulfilled the symptomatic criteria underwent a physical examination of the cervical spine for baseline assessment, which included manual palpation of the upper cervical joints relevant to the inclusion criteria.

Experiment protocol

A pilot study was conducted to find out the reliability of measurement of Joint position sense for neck rotation using magnetic inclinometer (Dover and Powers, 2003). Patient was placed supine on the table. The magnetic inclinometer was affixed to the patient's forehead. The inclinometer was positioned such, that the center of the inclinometer was in alignment with the tip of the nose. (Figure 1) Patients were instructed to close their eyes, nod a few times and then return their head to a comfortable resting position. They were allowed to choose any position of ease of their head. This became the neutral head position. Their head was then positioned at 30º of rotation and then returned to 0º with eyes closed. The patient was then asked to reproduce the angle three times with the eyes closed within a 60 second period. Three angles were recorded for right and left side rotation separately. The absolute difference for the target angle was calculated and used for statistical analysis.

The participants were evaluated at 0 day and at end of each week for Headache Disability Inventory (HDI) (Jacobson, Ramadan, Norris and Newman, 1995) scores and neck proprioception. The stabilization exercises were in accordance with the cervical stabilization exercise program given by the Thera-band Academy targeting the deep cervical flexor (DCF) muscles along with the muscles of the scapula, particularly the serratus anterior and lower trapezius, were trained using inner range holding exercises of scapular adduction and retraction. Each exercise was repeated 10 times with 10 second hold.

Cervical stabilization exercise

A 55cm diameter exercise ball was taken for the cervical stabilization exercise. Three types of exercise were given, out of which in first exercise where patients is in Quadruped position and asked him to place the exercise ball under his forehead while maintaining a 'neutral' position of his neck and be sure to avoid protracting his head into the ball. Hold for 10 seconds.(Figure 2) In second type of exercise subject has to Lay on ball and keep his back in neutral position. Slowly lift arm forward, keeping elbow straight. Hold and return after 10 seconds; repeat on other side. Keep ball steady.(Figure 3) In second type of exercise subject has to Place the exercise ball under his forehead as he stands next to a wall. Maintain a 'neutral' position of his neck and stabilize the ball with his head and don't let the ball move. Be sure to avoid protracting your head into the ball. Hold for 10 seconds.(Figure 4)

Stretching Exercises

Stretching was given for the tight muscles, particularly for upper trapezius (Figure 5), sternocleidomastoid, scalenes, levator scapulae, pectoralis major and minor, and short sub-occipital extensors. (Kisner and Colby, 2007)The stretching's comprised of a 30 second stretch followed by a 30 second pause, three times for each muscle. Both the interventions were repeated 3 times a week for 4 weeks, a total of 12 sessions.

STATISTICAL ANALYSIS

The data was analyzed using SPSS 17.0 for windows. A Pearson correlation coefficient (r) was calculated to test the reliability of the procedure for measuring neck proprioception. Independent sample t-test was performed to see any difference between the groups. One way analysis of variance (ANOVA) post-hoc Tukey test were used to determine if there was any difference the o day, 1st week, 2nd week, 3rd week and 4th week. The significance level was set at $p<0.05$.

RESULTS

Intraclass correlation coefficient values for intratester reliability were 0.813 for therapist one and 1 for therapist two; intertester reliability was 0.813. (correlation is significant at the 0.01 level (2-tailed)). Independent sample t-test between the groups showed significant difference at 3rd week for HDI and rotation (Rt) and at 2nd week for rotation (Lt). (Table 1,2,3) The one way analysis of variance (ANOVA) within the experimental group and control group showed significant difference. (Table 4,6) Multiple comparison test within the experimental group showed significant difference for HDI at the end of 2nd week, for rotation (Rt) at the end of 1st week, and for rotation (Lt) at the end of 2nd week. ($p<0.05$) (Table 5) Multiple comparison test within the control group showed significant difference for HDI at the end of 3rd week, for rotation (Rt) at the end of 2nd week, and for rotation (Lt) at the end of 3rd week. ($p<0.05$) (Table 7) This reveals that cervical stabilization exercise along with stretching is effective within first 2 weeks, and stretching alone is effective within first 3 weeks for improving HDI and neck proprioception. So the session required for improving HDI and neck proprioception with cervical stabilization exercise and stretching is 2 weeks and with stretching only is 3 weeks.

In Multiple comparison test within experimental group, the readings from 0 day to 4th week came significant for HDI, Rotation (Rt) and Rotation (Lt) with a mean difference of 23, 6.7 and 5.7 respectively. Likewise, within control group the readings from 0 day to 4th week came significant for HDI, Rotation (Rt) and Rotation (Lt) with a mean difference of 17.2, 6.8 and 4.7 respectively. This shows that cervical stabilisation exercises and stretching given to experimental group is more effective in reducing HDI and neck proprioception towards Rotation (Rt) as compared to only stretching given to control group.

Figure 1a
Starting position for measuring neck proprioception

Figure 1b
End position for rotation towards right side

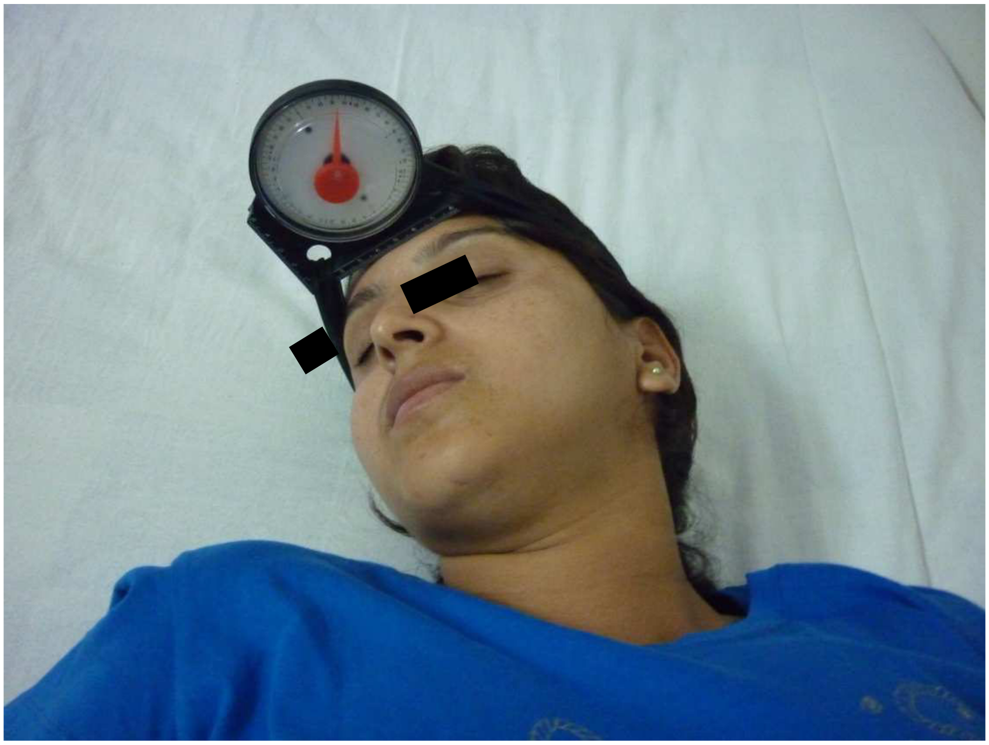

Figure 2
Exercise ball cervical stabilization in Quadruped

Figure 3
Exercise Ball Prone Shoulder Flexion


[redacted]

Figure 4
Exercise Ball Cervical Stabilization in Standing


[redacted]

Figure 5
Stretching of upper trapezius muscle (left side)

Figure 6
Mean comparison of HDI between Group A and B at 0 day, 1st week, 2nd week, 3rd week and 4th week.

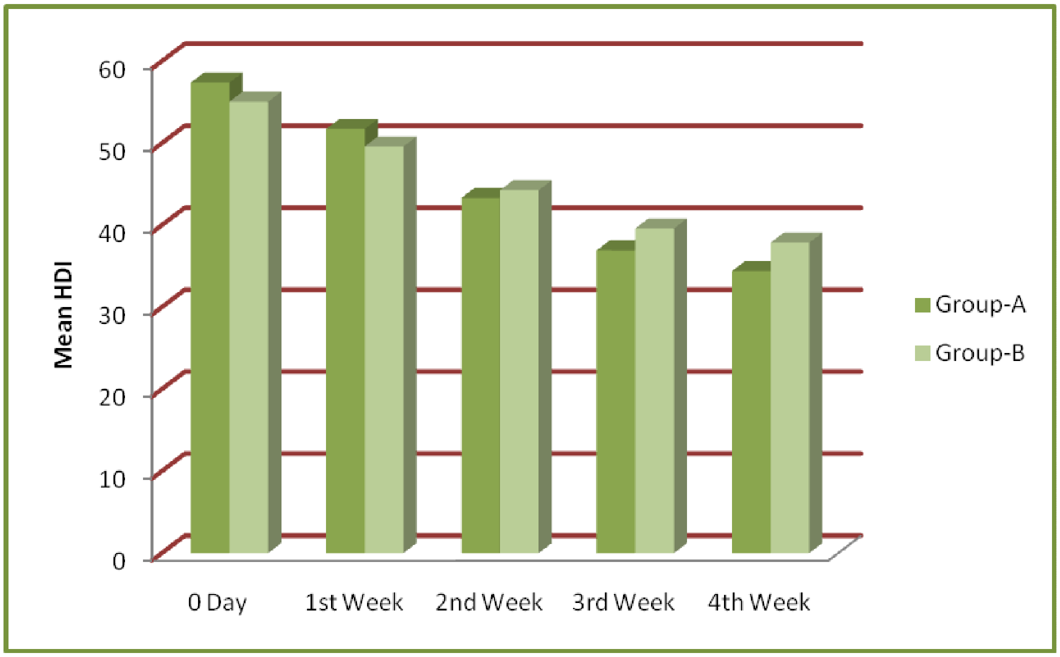

Figure 7

Mean comparison of JPS (Rt Rot) between Group A and B at 0 day, 1st week, 2nd week, 3rd week and 4th week.

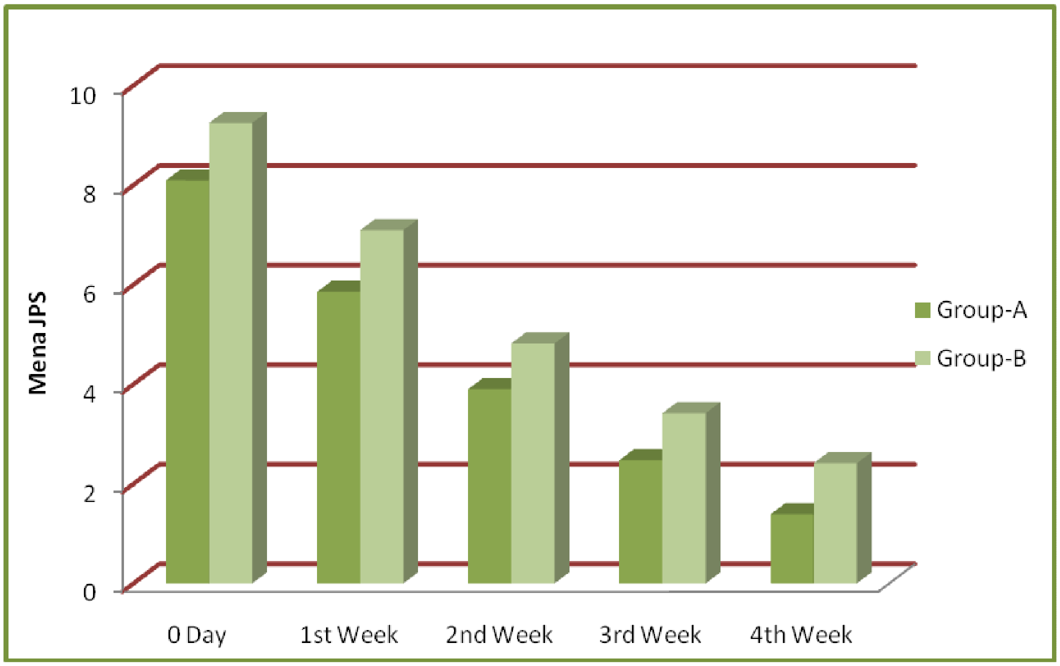

Figure 8

Mean comparison of JPS (Lt Rot)between Group A and B at 0 day, 1st week, 2nd week, 3rd week and 4th week.

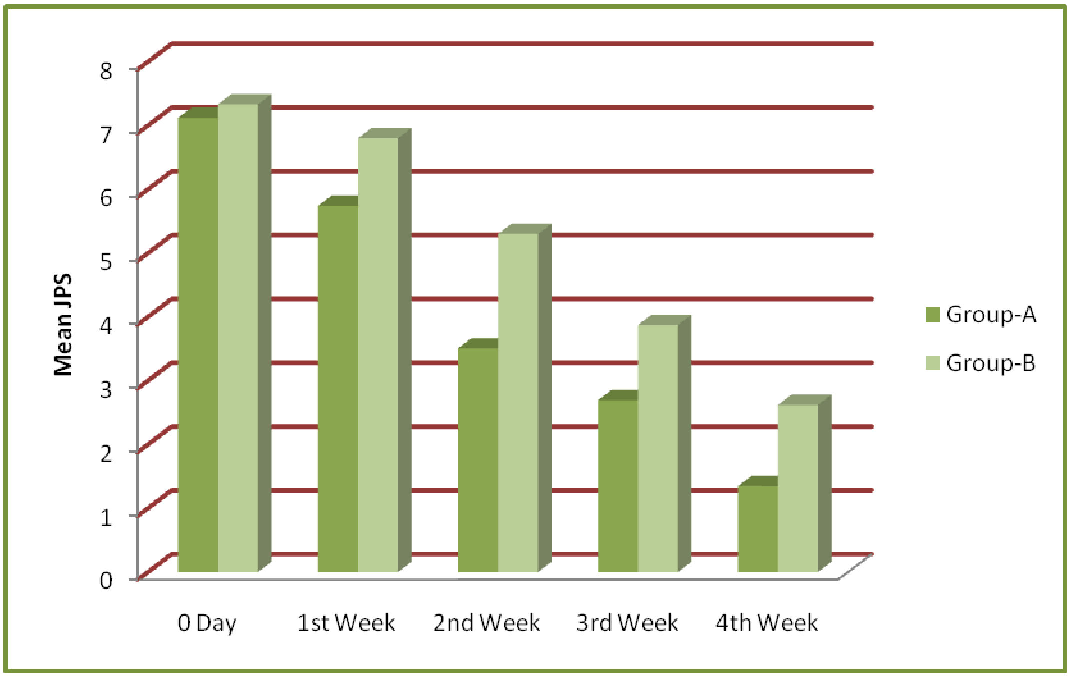

Figure 9
Mean comparison within Group-A at 0 day, 1st week, 2nd week, 3rd week and 4th week

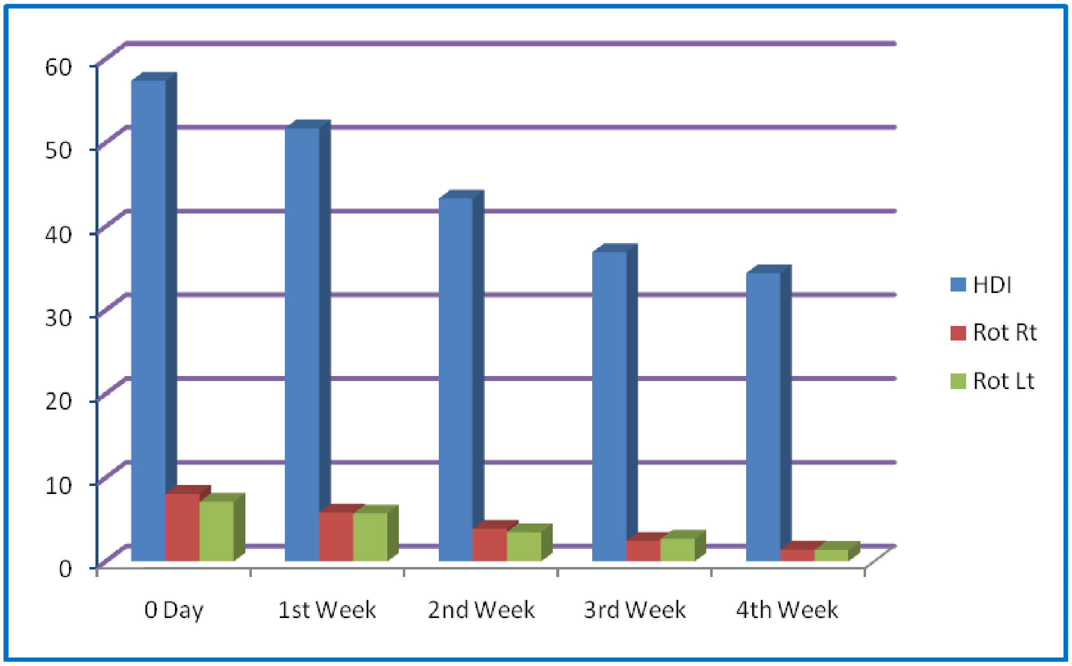

Figure 10
Mean comparison within Group-B at 0 day, 1st week, 2nd week, 3rd week and 4th week.

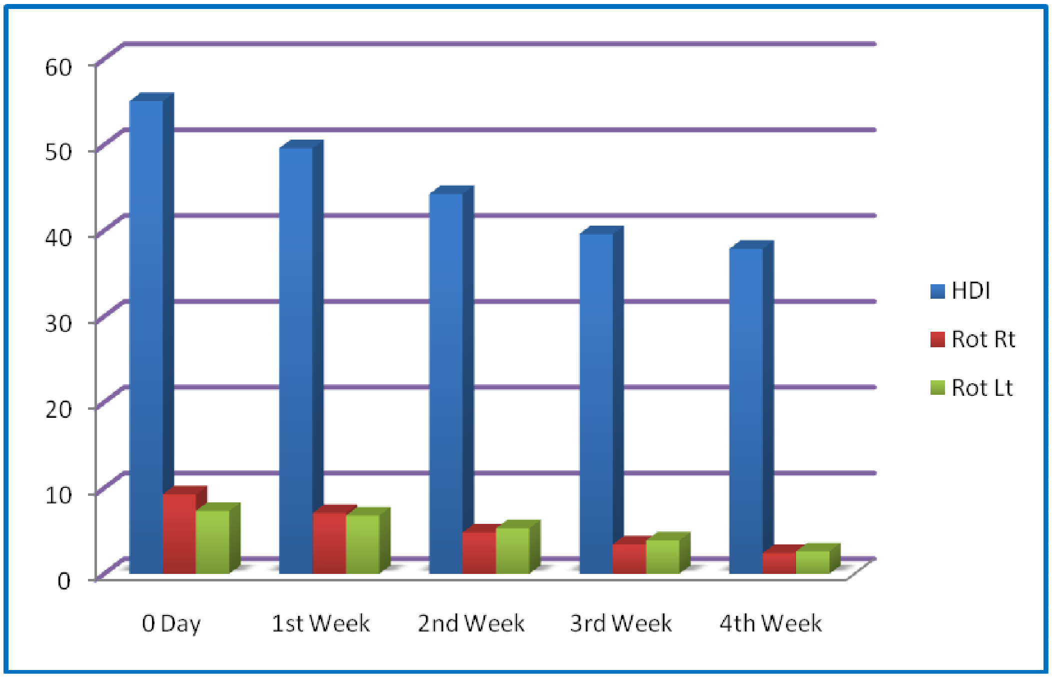

Table 1
Correlation coefficient of neck proprioception in normal subjects with cervicogenic headache

	Pearson value	p-value
Rotation right	0.974	0.0001
Rotation left	0.952	0.0001

Table 2
Independent sample t-test of HDI between the groups

	Mean difference	Standard error difference	t-value	p-value
0 week	9.066	3.868	2.344	0.026
1 week	3.600	2.922	1.232	0.228
2week	2.266	2.521	0.899	0.376
3week	7.600	2.485	3.057	0.005
4week	7.866	2.555	3.078	0.005

Table 3
Independent sample t-test of JPS in Rotation (Rt) between the groups

	Mean difference	Standard error difference	t-value	p-value
0 week	1.153	1.239	0.930	0.360
1 week	1.240	1.058	1.172	0.251
2week	0.920	0.597	1.539	0.135
3week	0.946	0.494	1.913	0.066
4week	1.026	0.397	2.585	0.015

Table 4
Independent sample t-test of Rotation (Lt) between the groups

	Mean difference	Standard error difference	t-value	p-value
0 week	0.2133	0.946	0.225	0.823
1 week	1.060	1.014	1.044	0.305
2week	1.793	0.792	2.262	0.032
3week	1.180	0.608	1.940	0.062
4week	1.273	0.480	2.650	0.013

Table 5
ANOVA within the Group-A

	F-value	p-value
HDI	12.524	0.0001
Rotation (Rt)	30.442	0.0001
Rotation (Lt)	31.949	0.0001

Table 6
Multiple comparison within the Group-A

		Mean difference	**Standard error difference**	**p-value**
HDI	0 day vs 1st week	5.666	3.890	0.714
	0 day vs 2nd week	14.066	3.890	0.016
	0 day vs 3rd week	20.466	3.890	0.000
	0 day vs 4th week	23.000	3.890	0.000
	1st week vs 2nd week	8.400	3.890	0.333
	1st week vs 3rd week	14.800	3.890	0.010
	1st week vs 4th week	17.333	3.890	0.001
	2nd week vs 3rd week	6.400	3.890	0.610
	2nd week vs 4th week	8.933	3.890	0.272
	3rd week vs 4th week	2.533	3.890	0.980
ROTATION (Rt)	0 day vs 1st week	2.240	0.687	0.040
	0 day vs 2nd week	4.193	0.687	0.0001
	0 day vs 3rd week	5.620	0.687	0.0001
	0 day vs 4th week	6.706	0.687	0.0001
	1st week vs 2nd week	1.953	0.687	0.101
	1st week vs 3rd week	3.380	0.687	0.0001
	1st week vs 4th week	4.466	0.687	0.0001
	2nd week vs 3rd week	1.426	0.687	0.375
	2nd week vs 4th week	2.513	0.687	0.015
	3rd week vs 4th week	1.086	0.687	0.647
ROTATION (Lt)	0 day vs 1st week	1.380	0.583	0.243
	0 day vs 2nd week	3.613	0.583	0.0001
	0 day vs 3rd week	4.426	0.583	0.0001
	0 day vs 4th week	5.773	0.583	0.0001
	1st week vs 2nd week	2.233	0.583	0.009
	1st week vs 3rd week	3.046	0.583	0.0001
	1st week vs 4th week	4.393	0.583	0.0001
	2nd week vs 3rd week	.813	0.583	0.746
	2nd week vs 4th week	2.160	0.583	0.013
	3rd week vs 4th week	1.346	0.583	0.266

Table 7
ANOVA within the Group-B

	F-value	**p-value**
HDI	5.951	0.0001
Rotation (Rt)	17.249	0.0001
Rotation (Lt)	8.426	0.0001

Table 8
Multiple comparison within the Group-B

		Mean difference	**Standard error difference**	**p-value**
HDI	0 day vs 1st week	5.466	4.126	0.780
	0 day vs 2nd week	10.800	4.126	0.157
	0 day vs 3rd week	15.466	4.126	0.011
	0 day vs 4th week	17.200	4.126	0.003
	1st week vs 2nd week	5.333	4.126	0.795
	1st week vs 3rd week	10.000	4.126	0.221
	1st week vs 4th week	11.733	4.126	0.101
	2nd week vs 3rdweek	4.666	4.126	0.864
	2nd week vs 4th week	6.400	4.126	0.663
	3rd week vs 4th week	1.733	4.126	0.996
ROTATION (Rt)	0 day vs 1st week	2.153	0.945	0.280
	0 day vs 2nd week	4.426	0.945	0.001
	0 day vs 3rd week	5.826	0.945	0.0001
	0 day vs 4th week	6.833	0.945	0.0001
	1st week vs 2nd week	2.273	0.945	0.228
	1st week vs 3rd week	3.673	0.945	0.008
	1st week vs 4th week	4.680	0.945	0.0001
	2nd week vs 3rd eek	1.400	0.945	0.701
	2nd week vs 4th week	2.406	0.945	0.179
	3rd week vs 4th week	1.006	0.945	0.888
ROTATION (Lt)	0 day vs 1st week	.533	0.960	0.989
	0 day vs 2nd week	2.033	0.960	0.354
	0 day vs 3rd week	3.460	0.960	0.017
	0 day vs 4th week	4.713	0.960	0.0001
	1st week vs 2nd week	1.500	0.960	0.657
	1st week vs 3rd week	2.926	0.960	0.065
	1st week vs 4th week	4.180	0.960	0.002
	2nd week vs 3rd eek	1.426	0.960	0.698
	2nd week vs 4th week	2.680	0.960	0.112
	3rd week vs 4th week	1.253	0.960	0.789

DISCUSSION

The study aimed to find the effects of cervical stabilization exercises on neck proprioception in patients with cervicogenic headache. The data analysis revealed that both the groups showed significant improvement in HDI and neck proprioception ($p<0.05$) within the group. Moreover the analysis between the group also showed significant difference (HDI $p=0.005$, rotation (Rt) $p=0.015$, rotation (Lt) $p=0.013$). On the basis of mean difference of HDI, proprioception in rotation (Rt) and rotation (Lt) we propose that cervical stabilization exercise can be considered as a better remedy for improving neck proprioception and disability for patients with cervicogenic headache as compared to conventional treatment. Stabilization exercises are given to improve the stability of the joint. Joint stabilization involves an intricate inter-relationship and precise control between several muscles acting on the joint to protect it during functional movement. Control of the continuous muscle recruitment for joint stability depends not only on the pre-programmed motor patterns from the cortex, but also on the state of the feedback system emanating from the kinaesthetic input (Richardson, Jull, Hodges and Hides, 1999). Improvement in proprioception after cervical stabilization exercises can be explained through the peripheral and central mechanisms that are responsible for regulating the proprioception.

At peripheral level, Proprioception has been thought to improve when muscles are contracted at a joint (Richardson, Jull, Hodges and Hides, 1992), likely as a result of increased fusimotor activity (γ-motor neurons activity) (Fitzpatrick and McCloskey, 1994). When the frequency of the discharge from γ motor neuron increases through exercise and stretching the activity of muscle spindle is also increased. This leads to increased discharge of impulses from the primary sensory nerve endings. The impulses stimulate the alpha (α) motor neuron of the spinal cord, in turn sending impulses to extrafusal fibers (Guyton and Hall, 2006).Subjects significantly increased spindle output when asked to tense the muscles within which the muscle spindles lay. This is an example of the alphagammacoactivation demonstrated by Granit, and it is evident that spindle output can be volitionally increased. This contraction of the muscles can be associated with the tightening of the passive joint structures and thus indirectly influences their ability to detect movement and joint position.

At central level, cervical stabilization exercise is able to change proprioception through the modulation of the muscle spindle gain and the induction of plastic modifications in the Central Nervous System. During physical activities an increase in the muscle spindle output through the γ (gamma) route is observed, which facilitates the cortical projection of proprioception. Thus, by increasing the output of the muscle spindle over time, it is possible to induce plastic changes in the Central Nervous System, such as increased strength of synaptic connections and/or structural changes in the organization and numbers of connections among neurons. These plastic changes in the cortex would modify the cortical maps of the body over time, increasing the cortical representation of the joints and leading to enhanced joint proprioception (Ashton-Miller, Wojtys, Huston and Fry-Welch, 2001). Cervical stabilization exercises incorporate proprioceptively mediated muscular control of joints that is appreciated through the CNS's influence on motor activities. Joint afferents contribute to CNS function at three distinct levels (Borsa PA, Lephart SM, Kocher MS, Lephart ,1994):

1. At the spinal level, reflexes subserve movement patterns that are received from higher levels of the nervous system. This provides reflex splinting during conditions of abnormal stress about the joint and has significant implications for rehabilitation. The muscle spindles play a major role in the control of muscular movements by adjusting activity in the lower motor neurons.
2. The second level of motor control is at the brain stem, where joint afferent is relayed to maintain posture and balance of the body. The input to the brain stem about this information emanates from the joint proprioceptors, from the vestibular centre in the ears, and from the eyes.
3. The final aspect of motor control includes the highest level of CNS function (motor cortex, basal ganglia, and cerebellum) and is mediated by cognitive awareness of body position and movements. Movements that are repeated can be stored as central commands and can be performed without continuous reference to consciousness.

   Proske, Morgan and Gregory (1993) showed that as the muscle spindles have a thixotropic property, stretching may improve proprioceptive input of muscular receptors. It has been suggested that static stretching may adjust the positional sensitivity of the muscular receptors by affecting the series elastic component of the muscles. This adjustment may begin early after stretching and involve recoil of the stretched elastic component of the tendon to a new equilibrium state (Bandy and Irion, 1994; Feland et al, 2001). Our results support these suppositions.

Because of important role muscle receptors in elaboration of limb position sense (McCloskey , 1978; Lattanzio and Petrof, 1998), stretching may improve sensory and motor capabilities of JPS perception. This improved JPS perception may be responsible for the increase in motor capabilities after stretching, which is due to a better proprioceptive feedback (Anderson and Burke, 1991; Shleip, 2003). It has been suggested that stretching enhances the sensibility of the intrafusalfibres of the muscle spindles and improves the performance of subsequent physical activity/ exercise. Accordingly, stretching may diminish the amount of error observed when measuring the JPS (Proske, Morgan and Gregory, 1993; Larsen et al, 2005). This suggested that the role of muscle spindles in improving the neck proprioception after stretching is more important than other proprioceptive receptors, as the discharge rate of the spindles is greater during lengthening among other muscular receptors (Hulliger, Nordh and Vallbo, 1985; Al Falahe, Nagoaka and Vallbo, 1990; Vallbo and Hagbarth, 1990).

Moore (2007) in his study concluded that GTO sensations reach the cerebral cortex, buried in the fissure between the motor and sensory cortex strips. This information allows us to know where the limbs are in space. GTOs also provide unconscious proprioception, via the cerebellum, which helps to learn new motor skills and improve execution of movements. In our study, the advantage of stabilization exercises over stretching was observed especially for the results of the HDI, suggesting that stabilization exercises may be more effective in improving disability. Since disability, is usually accompanied by a substantial effect on daily life, resulting in an extensive use of healthcare resources, to improve the patient's disability or enable them to return to normal activity may be the main aim of any treatment approach. With regard to our results, cervical stabilization exercises may be a better approach to meeting this purpose.

Jull, Trott and Potter (2002) in his trial identified that manipulative therapy and low-load exercise produce similar responses in the pain system. Both treatment methods were likely to induce quite local afferent input into the system to modulate pain perception. The afferent input induced may stimulate neural inhibitory system at various levels in the spinal cord (Allen, Terrett and Vernon, 1984; Bansevicius and Sjaastad, 1996), and may also activate descending inhibitory pathways from, for example, the lateral periaqueductal gray area of the midbrain (Wright, 1995; Vicenzino, Collins, Benson and Wright, 1998). Ylinen et al (2010) reviewed that chronic pain is commonly associated with compression hyperalgesia of tissues in the local area (Fisher, 1988). A lower pressure pain threshold has been found in cervicogenic headache patients compared with healthy controls and patients with other types of headache (Boviml, 1992). Specific exercises involving intensive neck muscle contraction that exceeds the muscular effort used in ordinary daily living has been shown to induce local hypoalgesia both immediately post-exercise (O'Leary et al, 2007) and in the long term (Ylinen et al, 2005). An exercise frequency of 3 times a week was also found to have an important impact on the results (Nikander, 2006).

On stretching inhibition of the contractile components of muscle by the GTO contributes to reflexive muscle relaxation (autogenic inhibition), enabling a muscle to be elongated against less muscle tension. When low-intensity, slow stretch force is applied on muscle for prolonged duration; the stretch reflex is less likely to be activated as the GTO fires and inhibits tension in the muscle, allowing the parallel elastic component (the sarcomeres) of the muscle to remain relaxed and to lengthen (Kisner and Colby, 2007). The limitation of the study was that biomechanical factors within the cervical spine were not taken into consideration. In conclusion, cervical stabilization exercises along with stretching were shown to be an effective treatment for headache and improving neck proprioception. In future follow-up of this study can be done.

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