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The immediate effect of manipulation and muscle energy technque versus muscle energy technique alone on pain and range of motion in subjects with chronic neck pain: A randomised controlled trial

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Abstract
Background and Objectives: In routine life style various causes traumatic, inflammation, degenerative changes alters the biomechanics of cervical spine produce chronic neck pain, reduce the active ROM, reduce functional mobility and produce disability in neck. There for the present study aims to evaluate the effectiveness of HVLAT manipulation with muscle energy technique versus muscle energy technique alone in subjects with chronic neck pain as assessed by VAS, ROM, NDI and PSFS.
Materials and Methods: A randomized controlled trial study was done and 120 subjects with diagnosis of chronic neck pain mean age 18-45 years both male and female were included in the study. Group A received HVLAT manipulation and Muscle Energy Technique and Group B received Muscle Energy Technique alone. The outcome was assessed in terms of Visual analog scale (VAS), active cervical ROM, Neck Disability Index (NDI) and Patient Specific Functional Scale (PSFS) at baseline and immediately post intervention.The intervention was given once and each session lasts for 15-30 minutes. Data was analyzed by Paired and Unpaired T Test, Wilcoxon signed rank test, Mann Whitney U Test.
Results: Data analysis and results showed that both the groups demonstrated statistically significant improvements in pain, range of motion, reduction in disability scores and improvement in patient specific functions ($P<0.05$) following intervention.
Conclusion: The combined therapy of HVLAT manipulation with Muscle Energy Techniques showed superior results as compared to the groups receiving Muscle Energy Techniques alone.

Keywords: Chronic neck pain, HVLAT manipulation, muscle energy techniques

Introduction
The Neck comprises the region between the thoracic inlet and the base of the head, which gives human so much of freedom of movement that it plays an important and major role in evolution of the human brain. It allows for improved movement and dexterity in terrestrial and Arial environments [1]. Its various articulations with complex musculo-fascial arrangement controls and allows for the protected passage of the blood supply to the head as well as to the upper respiratory and digestive tracts while also allowing complex high degree motion of the head and neck and between the neck`s internal structures [1]. Musculoskeletal pain and other symptoms in neck are common subjective health complaint, typically characterized by self-reported pain experienced in the cervical region. It is a common musculoskeletal disorder in the general population. Often disorders of the cervical spine include neck pain with or without radiation to the upper limb and headache. The pain may arise from several structures in the cervical region, including the joints and the soft tissues.[1]It is one of the most prevalent musculoskeletal conditions in western society usually associated with a sedentary life and monotonous repetitive task based works eg. A white collar official will also have high socioeconomic costs in terms of health expenses and loss in working days. The etiology of these musculoskeletal pain symptoms could be multifactorial which involve several physical and psychosocial risk factors [2]. It is a discomfort that can be due to involvement of any of the structures in the neck including muscles and nerves as well as spinal vertebrae and the cushioning disks in between,

may be located anywhere between the occiput and upper thoracic spine and surrounding muscles, with or without radiations to the upper extremities. It may also come from areas near the neck such as the shoulder, jaw, head, and upper arms [3]. Chronic neck pain is described as an often widespread sensation with hyperalgesia in the skin, ligaments, and muscles on palpation and in both passive and active movements in neck and shoulder area. It is a common problem in the general population and is associated with varying degrees of disability. It has been estimated that two-thirds of the population will suffer from neck pain at some point in their lifetime [4]. The international association for the study of pain (IASP) in its classification of chronic pain defines cervical spinal pain as pain perceived anywhere in the posterior region of the cervical spine, from the superior nuchal line to the first thoracic spinous process. Another type of classification proposed by IASP is based on duration of neck pain according to which chronic neck pain has duration of 3 months or more [5]. It is a common painful musculoskeletal condition affecting up to 70% [4] of individuals at some point in their lives and about second largest cause of disability and time off work; after low back pain. Its prevalence varies from 9.5% to 35% [4], although the most common point prevalence is 10% to 15% [4]. The reported prevalence is somewhat higher in females as compared to males [6]. In fact, 10% [5] of people will have neck pain in any given month. Potential pain generators include bones, muscles, ligaments, facet joints, and intervertebral discs. Almost any injury or disease process within the neck or adjacent structures will result in reflexive protective muscle spasm and loss of motion [7]. Its multifactorial nature of etiology and impact on individual to individual with origin and exact pathophysiologic mechanisms often remain obscure because trauma or severe degenerative conditions at working age are found only in a few cases. Patients with chronic neck pain often complain of discomfort during daily activities with common feature being reduction of cervical range of motion [8]. When cervical region is stiff, the less involved area compensates for the loss of motion. At the level immediately above the stiff region, the ligaments gradually elongate and permit the vertebra to glide forward and backward through a greater than normal range so that they may appear to slightly subluxed [9]. The physiological factors contributing towards chronic neck pain could be the response of specific anatomic structures, the anatomic features of the structures, the presence of inflammation, any degeneration occurring, and electrophysiological sensitivity [10]. The cervical spine is a mechanical structure designed to protect the spinal cord. The vertebrae articulate with each other in a controlled manner through a complex of levers (vertebrae), pivots (facets and discs), passive restraints (ligaments) and activators (muscles) with three basic fundamental biomechanical functions; they are stability, mobility and flexibility. Any interference in the biomechanics of the spine causes spinal problems because its complex structure that is highly susceptible to irritation [11]. The cervical spine consists of three atypical and four typical vertebrae. The typical cervical vertebrae, C3 to C6 comprise a vertebral body, a vertebral arch, and several processes for muscular attachments and articulation. The musculo-fascial arrangement of the neck allow the protected passage of the blood supply to the neck as well as the upper respiratory tract and the digestive tract while allowing complex motion of the head and neck and between the neck`s internal structures [1]. The vertebral body provides the strength and support for two- third of the vertebral load. The depth of the vertebral body at the inferior end plate is consistently larger than the depth of the superior end plate except at C7 [11]. The first, second and the seventh cervical vertebrae are considered atypical. C1 or the atlas lacks a body and a spinous process. It is a ring shaped structure consisting of two lateral masses connected by a short anterior arch and a longer posterior arch. The axis or the second vertebrae is also known as the epitrophysis. It is characterized by dens or odontoid process that projects upward from the body of C2 to articulate with the posterior aspects of the anterior arch of C1 [11]. The seventh cervical vertebrae is characterized by a long spinous process and has thus been given the name vertebrae prominens. There is rarely a foramen transversarium at C7, and when present it usually does not contain the vertebral artery. The transverse process is large and although the costal component of the transverse process is usually small, it may develop secondarily to form a cervical rib [11]. In neck there is three degree of freedom of motion. The motion of flexion and extension in sagittal plane, lateral flexion coronal plane, and rotation in transverse plane are permitted in the neck region. Total range of flexion across cranio-cervical region is 45º-50º, extension 85º, rotation (on either side) 80º-90º with lateral flexion (on either side) 40º [11]. A mild sprain is the most common type of injury, involves mainly the muscles, and symptoms last only for few days. The immediate discomfort is minimal but discomfort intensifies over hours, causing pain and limited range of motion [9]. A moderate sprain involves the ligaments, and the symptoms extend well beyond the usual time required for the recovery of ligament sprain. The initial momentary pain is followed by an interval of an ache that is intensified by any movement that exerts tension on the affected ligament. Pain is often generalized above the neck and referred to some distant area like the occiput, scapula or upper extremity [9]. A severe sprain, by definition, is one in which complete interruption of the ligaments takes place, there has been a severe hyper flexion or hyperextension injury, symptoms are intense, signs of instability are superimposed and disability is prolonged. The mechanical factors that contribute to neck pain can be attributed to magnitude of load, the magnitude of deformation, the direction of application, the rate of application and the duration of application [9].

A primary goal of diagnosis is to match the patient's clinical presentation with the most efficacious treatment approach. A component of this decision is determining whether the patient is, in fact, appropriate for physical therapy management. In the vast majority of patients with neck pain, symptoms can be attributed to mechanical factors. However, in a much smaller percentage of patients, the cause of neck pain may be something more serious, such as cervical myelopathy, cervical instability, fracture, neoplastic conditions, vascular compromise, or systemic disease [12]. Therapists must be aware of the key signs and symptoms associated with serious pathological neck conditions, continually screen for the presence of these conditions, and initiate referral to the appropriate medical practitioner when a potentially serious medical condition is suspected [13]. There are various forms of intervention for the treatment of neck pain, the most commonly used are soft tissue mobilization [14], strain constrain [14], joint mobilization [16],

muscle energy techniques [17], high velocity low amplitude thrusts [16], stretching and various electro/thermal modalities etc. [15] The term manipulation is often used to describe a range of manual therapy technique which focuses on the high velocity and low amplitude thrusts, commonly utilized for the treatment of pain and dysfunction. It is defined as a localized force of high velocity and low amplitude directed at any joint segment. The aim of a high velocity low amplitude thrust technique is to achieve joint cavitation that is accompanied by popping or cracking sound [16]. Muscle energy technique is an established osteopathic manipulative intervention often used to treat somatic dysfunctions of the spine. It is a revolution in manipulative therapy involving a movement away from high velocity low amplitude thrusts. This approach is a soft tissue primarily; it also makes a major contribution towards joint mobilization [17-18]. In addition to using muscle effort to mobilise joints and tissues, MET is considered by some to be a biomechanics-based analytic diagnostic system that uses precise physical diagnosis evaluation procedures to identify and qualify articular range of motion restriction. Recent research suggests a revision of MET concepts and practices is required, particularly considering the trend towards evidence-based medicine (EBM) [17]. It produce changes in proprioception, motor programming, and control. Spinal pain disturbs proprioception and motor control, causing decreased awareness of spinal motion and position and cutaneous touch perception. Since MET produces joint motion while actively recruiting muscles, it may affect Proprioceptive feedback, motor control, and motor learning [17]. A recently published clinical practice guideline concluded that the evidence for combined intervention was relatively strong, while the evidence for the effectiveness of thrust or non-thrust manipulation in isolation was weaker [18]. Tseng *et al* reported 6 predictors for patients who experienced an immediate improvement in either pain, satisfaction, or perception of condition following manipulation of the cervical spine. These include: (i) Initial scores on NDI less than 11.5 (ii) Having bilateral involvement pattern (iii) Not performing sedentary work more than 5 hours per day (iv) Feeling better while moving the neck (v) Did not feel worse while extending the neck and (vi) The diagnosis of spondylosis without radiculopathy. The presence of 4 or more of these predictors increased the probability of success with manipulation [19].

Outcome measures assessing subjects with neck pain are used widely in research and in clinical settings to establish baselines, to evaluate the effect of an intervention, to assist in goal setting, and to motivate patients to evaluate their treatment. Because of the multifactorial nature of chronic neck pain, either multidimensional indexes or more than one index may be needed to gain a complete health profile of the patient with neck pain. Hence therapists should use validated self-reported questionnaires, such as the Neck Disability Index [20] (NDI), Visual Analogue Scale (VAS) [21] and the Patient-Specific Functional Scale (PSFS) [22] for subjects with neck pain. These tools are useful for identifying a subject's baseline status relative to pain, function, and disability and for monitoring a change in subject's status throughout the course of treatment. Another outcome measure such as cervical range of motion can be measured by using universal goniometer and recently it has been validated and found to be reliable in subjects with neck pain [23-25]. The visual analog scale (VAS) is generally used to assess the intensity of the patient's pain. In order to measure the pain Visual Analogue Scale (VAS) is a valid and reliable tool in clinical research. This is a continuous scale that ask patients to think about their present neck pain and to rate their pain level by marking on a 100-mm line, anchored with "no pain" and the "worst pain you have ever felt." This is a well-accepted method of documenting pain intensity levels. The VAS is a well-studied method for measuring both acute and chronic pain, and its usefulness has been validated by several investigators [21]. Universal Goniometer is the best reliable method in measuring range of motion in recent clinical scenario. In one study, the reliability of universal goniometer to measure cervical motion was found to be excellent [23]. The Neck Disability Index is a commonly utilized outcome measure to capture perceived disability in patients with neck pain [20]. The NDI contains 10 items, 7 related to activities of daily living, 2 related to pain, and 1 related to concentration [50]. Each item is scored from 0-5 and the total score is expressed as a percentage, with higher scores corresponding to greater disability. The NDI questionnaire has been cited in the literature as the criterion standard for many other questionnaires [20]. The Patient-Specific Functional Scale (PSFS) [22] is a practical alternative or supplement to generic and condition-specific measures. The PSFS asks patients to list 3 activities that are difficult as a result of their symptoms, injury, or disorder. The patient rates each activity on a 0-10 scale, with 0 representing the inability to perform the activity, and 10 representing the ability to perform the activity as well as they could prior to the onset of symptoms. The PSFS has been evaluated for reliability and validity in patients with neck pain.

Although, MET differs from HVLAT in that it is an active technique requiring the patient to contribute the corrective force. MET has been described as a valuable treatment technique because of the many claimed therapeutic benefits resulting from a single procedure, including lengthening and strengthening muscles, increasing fluid mechanics and decreasing local edema, mobilizing restricted articulations and reducing pain and disability [26-29]. The cervical spine is the ideal area, in which the application of muscle energy techniques especially of chronic problems involving muscle spasm and for problems that have a high level of irritability. The objective of the therapy is to relax the muscles at the affected level, increase its length and movement, and thus increase the range of movement of the joint [30] Not many studies were found wherein High-velocity, low-amplitude manipulation and muscle energy technique where combined. Hence a need arises to find out whether muscle energy technique when added with high velocity low amplitude manipulation will show additional effects in the outcome measures during recovery for the subjects with chronic neck pain than muscle energy technique alone.

Methodology

A randomized controlled trial study of 120 subjects (both male and female) using simple random sampling and allocation with envelop method was done. A sticker containing letters A (muscle energy technique and HVLAT) or B (muscle energy technique) was inside the envelope. After reading the sticker it was attached to subjects file. Based on the article by Cassidy *et al*, sample size was calculated assuming the power of the test as 0.80 and effect size of 0.5 with P value 77 and Q value 23, the minimum

sample size required was 60 in each group, the formula was used as follows. Formula N=2(Zα+Zβ) 2×pq/ (p1-p2)2, P1=69 P2=85 α=0.05 Zα=1.96, taking the power of the test as 80%, Zβ=0.84, based on the article (P) p=77, q=23.Subjects which were suffered from chronic neck pain aged between 18-45 years included according to inclusion and exclusion criteria. The intervention both HVLAT and MET were implemented once. Outcome measures were assessed for pain by Visual Analogue Scale (VAS), range of motion of the cervical spine by a universal goniometer, functional status using neck disability index and patient specific measures by patient specific functional scale. These outcome measures were obtained before and after the treatment session and then were compared for analysis. The inclusion criteria for this were both male and female suffered from chronic neck pain age between 18-45 years whose those willing to participate in this study diagnose with chronic neck pain and somatic dysfunction referred to the physiotherapy department by the orthopaedician [16] and exclusion criteria for the study subjects with neurological conditions with radiating pain to the upper limb, treatment position if cannot be achieved because of pain or resistance for muscle energy technique or manipulation, if participants had received cervical spine manipulation in the previous three days, red flags for cervical thrust manipulation such as: fractures, dislocation, subluxation, or any severe spinal tumor's, bone infection, instability of the cervical spine, vertebro-basilar insufficiency, nerve root compression with motor involvement or increasing neurological deficit or cord compression, cervical myelopathy, fibromyalgia syndrome, long term cortico-steroid user, acute wry neck, osteoporosis, spondylosis, spondylolisthesis, subjects with fever, pregnancy, previous history of whiplash injury, history of cervical spine surgery, chronic headaches and previous history of trauma.

Outcome Measures

VAS-Visual analog scale (universal pain rating scale, 100 point) used to measure pain because of its sensitivity and specificity.

Universal goniometer –reliable and valid tool to measure range of motion of the cervical spine.

NDI (neck disability index) and (PSFS) Patient Specific functional scale- used to measure functional status of the neck.

As the study includes human subjects ethical clearance is received from Institutional Ethical Committee of K.T.G. College of physiotherapy and K.T.G. Hospital Bangalore reference no. KTG/CPT/19/133. As per the ethical guidelines for Bio-medical research on human subjects, 2000 ICMR, New Delhi.

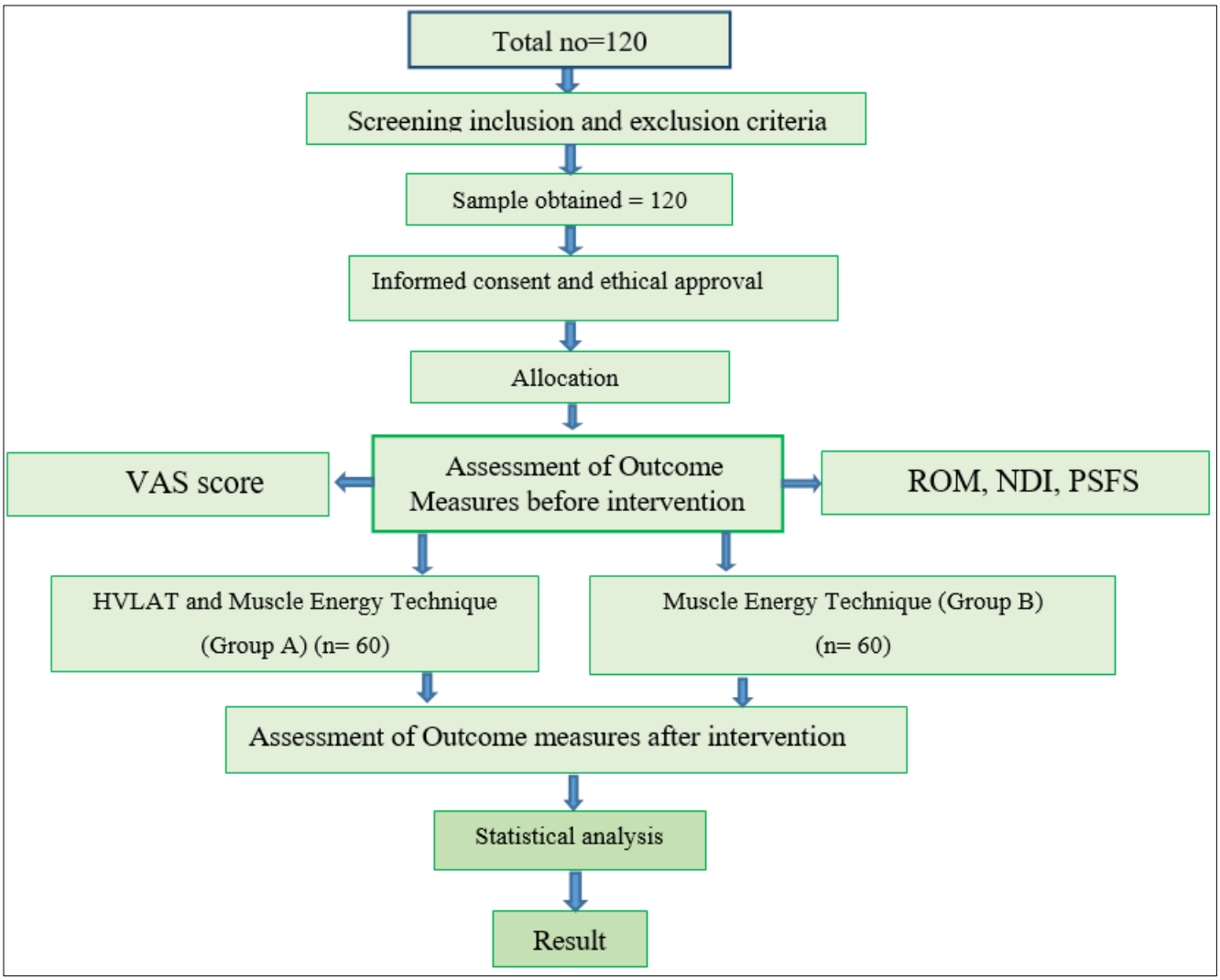


Fig 1.1: Flow chart representing the procedure of selection of patients.

Results

Data was analyzed by Paired and Unpaired t test. Wilcoxon signed rank test, Mann Whitney U test. All statistical analysis was done with utilizing SPSS-18.20 software, excel sheet, InStat and $p<0.05$ is considered as level of significance.

VAS Score: The mean difference in group-A and group-B after intervention was 4.8±1.07 and 4.3±1.34 respectively.

ROM: Flexion-The mean difference in group-A and group-B after intervention was -11.58±7.39 and -8.17±6.95 respectively.

Extension-The mean difference in group-A and group-B after intervention was -9.33±7.28 and -7.08±7.44 respectively.

Lat. Flexion (Rt)-The mean difference in group-A and group-B after intervention was -11.67±6.93 and -7.68±7.28 respectively.

Lat. Flexion (Lt)-The mean difference in group-A and group-B after intervention was -12.33±6.07 and -7.92±7.44 respectively.

Rotation (Rt)-The mean difference in group-A and group-B after intervention was -13.42±6.80 and -8.25±8.12 respectively.

Rotation (Lt)-The mean difference in group-A and group-B after intervention was -18.75±9.94 and -7.83±7.21 respectively.

NDI-The mean difference in group-A and group-B after intervention was 45.2±8.41and 17.83±10.27 respectively.

PSFS-The mean difference in group-A and group-B after intervention was-3.6±1.13 and-4.2±1.10 respectively.

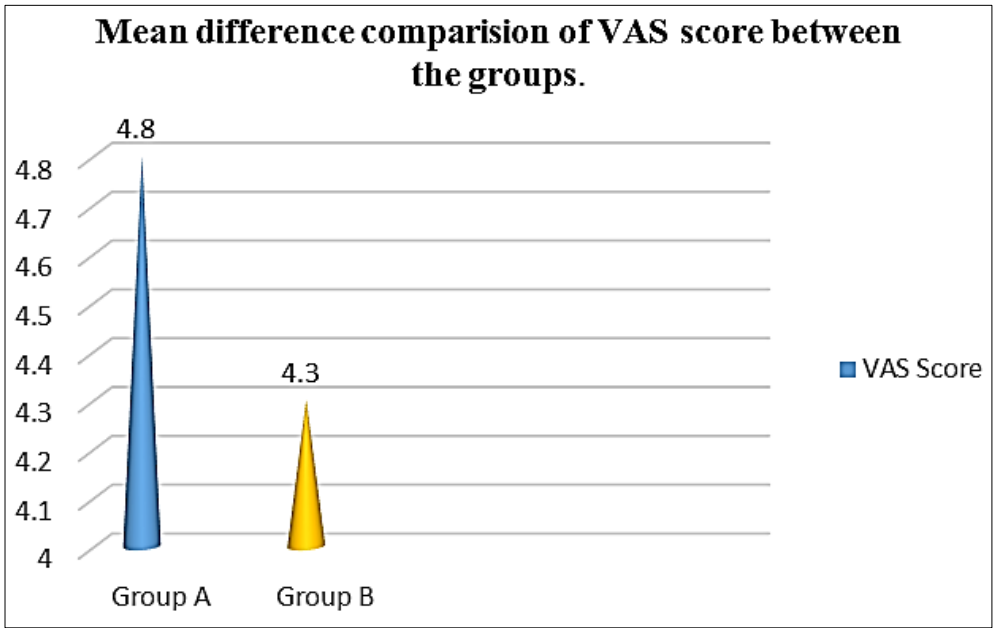
Table 1.1: Group characteristics

		Group A(n= 60)	Group B(n=60)
Age (yrs)		38.3 ± 11.0	40.0 ± 9.9
Sex	Male	32 (53.3%)	32 (53.3%)
	Female	28 (46.7%)	28 (46.7%)
VAS score (cm)	Baseline	7.0 ± 1.1	7.1 ± 1.1
NDI score (%)	Baseline	60.3 ± 7.5	56.7 ± 10.3
PSFS score (%)	Baseline	2.9 ± 0.7	2.8 ± 0.7

VAS= Visual analogue scale; NDI= Neck disability index; PSFS= Patient specific functional scale. Note: Values are mean ± SD or numbers and percentages (%).

Table 1.2: Mean difference comparison VAS score of both the groups.

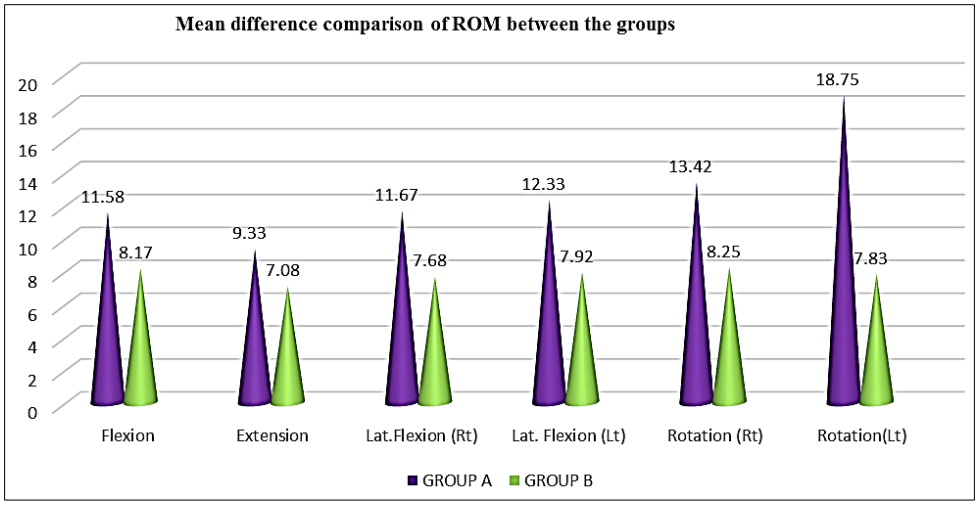
Outcome Measure	Groups	Pre	Post	MD (mean difference)	Z-value/ p-value	U-value
VAS Score	Group A	7.0±1.1	2.2±0.7	4.8±1.07	-0.4540/0.6498	1713.5
	Group B	7.1± 1.1	2.8±0.93	4.3±1.34	-3.4956/0.0005*	1134.0



Graph 1.1: Mean difference comparison of VAS score between the groups.

Table 1.3: Mean difference comparison ROM of both the groups.

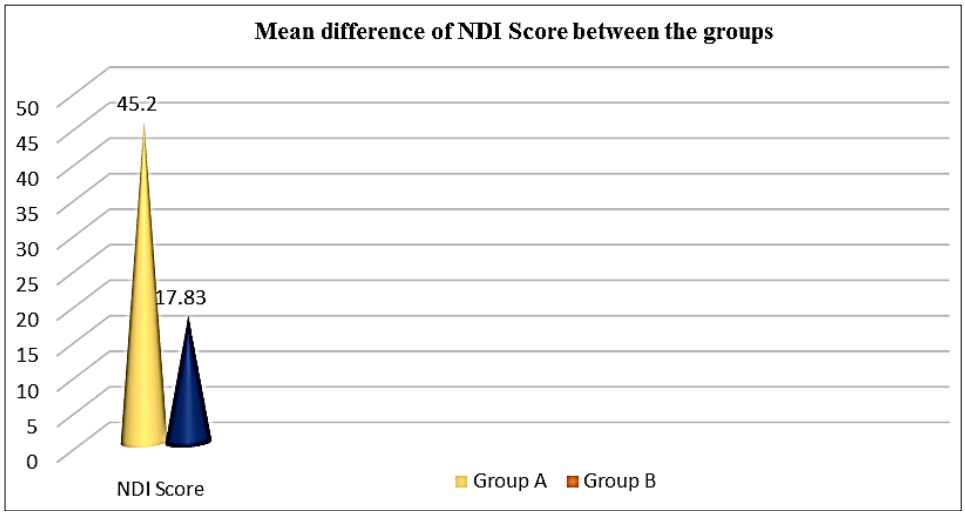
Outcome Measure	Groups	Variable	Pre	Post	MD (mean difference)	t-value	p-value
ROM	Group A	Flexion	31.00±8.53	42.58±6.28	-11.58±7.39	0.0000	-12.1366
		Extension	32.67±8.46	42.00±6.71	-9.33±7.28	0.0000	-9.9364
		Lat. Flexion (Rt)	30.17±8.78	41.83±7.36	-11.67±6.93	0.0000	-13.0407
		Lat. Flexion (Lt)	30.08±6.61	42.42±5.93	-12.33±6.07	0.0000	-40.99
		Rotation (Rt)	31.75±8.63	45.17±7.25	-13.42±6.80	0.0000	-42.27
		Rotation (Lt)	30.67±9.85	49.42±5.82	-18.75±9.94	0.0000	-14.6091
	Group B	Flexion	28.00±6.96	36.17±6.53	-8.17±6.95	0.0000	-9.1044
		Extension	33.42±8.00	40.50±5.58	-7.08±7.44	0.0000	-7.3761
		Lat. Flexion (Rt)	36.07±8.02	43.75±6.48	-7.68±7.28	0.0000	-8.1724
		Lat. Flexion (Lt)	34.92±8.56	42.83±7.15	-7.92±7.44	0.0000	-8.2439
		Rotation (Rt)	37.17±11.14	45.42±7.09	-8.25±8.12	0.0000	-7.8688
		Rotation (Lt)	37.92±10.94	45.75±6.30	-7.83±7.21	0.0000	-8.4139



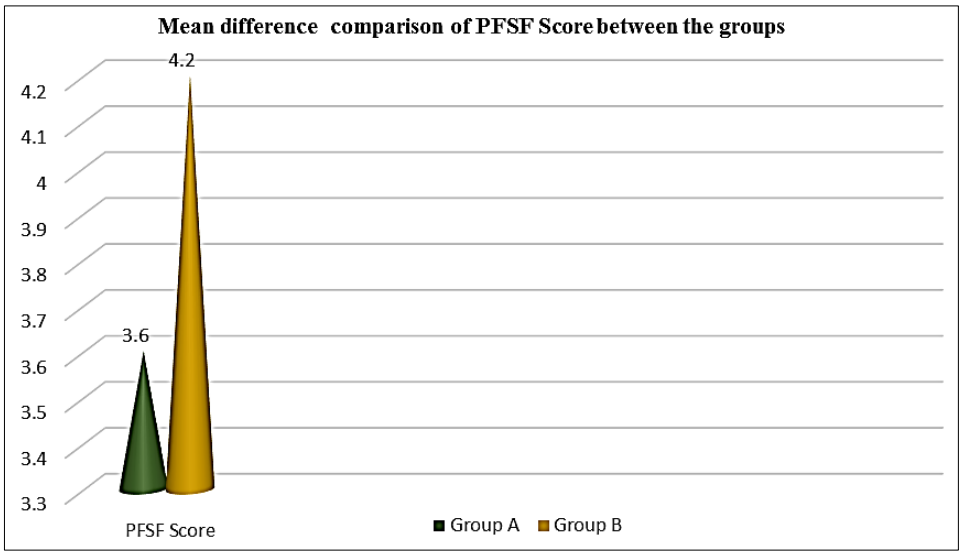
Graph 1.2: Mean difference comparison of ROM between the groups.

Table 1.4: Mean difference comparison NDI and PFSF scores between the groups.

Outcomes	Group	Pre	Post	MD (mean difference)	t-value	p-value
NDI	A	60.3±7.50	15.1±2.81	45.2 ±8.41	41.60	0.0000*
	B	56.7±10.31	38.9±6.94	17.83±10.27	13.5	0.0000
PFSF	A	2.9±0.77	6.5±0.92	-3.6±1.13	0.4	0.7180
	B	2.9±0.75	7.03±0.9	-4.2±1.10	-3.76	0.0004



Graph 1.3: Mean difference comparison NDI score between the groups.



Graph 1.4: Mean difference comparison of PFSF score between the groups.

Table 1.5: Effect size scores after treatment.

Outcome measure	Group A	Group B
VAS	5.1	4.2
NDI	8.8	2.1
PSFS	4.2	5.2
Range Of Motion		
Flexion	1.6	1.2
Extension	1.2	1.1
Lat. flexion(Rt)	1.4	1.1
lat flexion(Lt)	1.9	1.0
Rotation(Rt)	1.7	0.9
Rotation(Lt)	2.4	0.9

Discussion

The result obtained in this study indicates that, there was highly significant difference in VAS score, ROM, NDI and PSFS score values after intervention.

Visual analog score (VAS) Score: VAS values in group A, mean difference after intervention was 4.8±1.07 and in group B mean difference after intervention was 4.3±1.34.

ROM: Flexion- values in group A, mean difference after intervention was -11.58±7.39 and in group B mean difference after intervention was -8.17±6.95.

Extension- values in group A, mean difference after intervention was -9.33±7.28 and in group B mean difference after intervention was -7.08±7.44.

Lat. Flexion (Rt)-values in group A, mean difference after intervention was -11.67±6.93 and in group B mean difference after intervention was-7.68±7.28.

Lat. Flexion (Lt)-values in group A, mean difference after intervention was -12.33±6.07 and in group B mean difference after intervention was -7.92±7.44.

Rotation (Rt)-values in group A, mean difference after intervention was -13.42±6.80 and in group B mean difference after intervention was -8.25±8.12.

Rotation (Lt)- values in group A, mean difference after intervention was -18.75±9.94 and in group B mean difference after intervention was -7.83±7.21.

NDI-values in group A, mean difference after intervention was 45.2 ±8.41 and in group B mean difference after intervention was 17.83±10.27.

PSFS-values in group A, mean difference after intervention was -3.6±1.13 and in group B mean difference after intervention was -4.2±1.10.

The present study demonstrated that cervical HVLAT manipulation along with muscle energy technique was more effective in reducing neck pain, increasing the active cervical range of motion, decreasing the disability and increasing patient specific functions as compared to control mobilization procedure such as muscle energy technique alone in subjects suffering from chronic neck pain. The results from the present study differed from the previous research by Cassidy *et al*. [14] who found a relationship between a decrease in neck pain and in increase in cervical ROM, but only significant for rotation motions. Because of the small sample size of the Cassidy *et al* study, there was a greater probability of creating a type 2 error. Our results are in agreement with previous studies. Pikula also found greater decreased neck pain and increased cervical range of motion with a cervical manipulation than with detuned ultrasound therapy [54]. Vernon *et al*. reported that cervical manipulation produced significantly higher increases in pressure pain threshold of tender points surrounding a cervical dysfunction in subjects with mechanical neck pain [55]. Ferna´ndez-de-las-Pen˜as *et al*. have recently demonstrated that a supine cervical rotation manipulation resulted in increased intersegmental motion at the dysfunctional side of a cervical vertebra as measured with plain film radiographs during contralateral cervical side flexion [56]. Previous and current findings suggest that spinal manipulative therapy is more effective in reducing pain threshold and increasing cervical range of motion than control mobilization procedure, muscle energy techniques, or detuned ultrasound therapy. The chronicity of spinal dysfunction may influence the choice of treatment technique and approach. The aetiology of segmental dysfunction is speculative, but acute dysfunction may arise from minor trauma, producing minor strain and inflammation in the spinal unit. In acute or recurrent spinal conditions, zygapophysial joint sprain and effusion may produce local pain and limited motion (active and passive). Following strain and inflammation, nociceptive pathways may be activated and initiate a cascade of events, including the release of neuropeptides from involved nociceptors that promote tissue inflammation. This neurogenic inflammation may outlast the tissue damage and contribute to tissue texture abnormality. Additionally, central nervous system motor strategies may be altered to inhibit deep paraspinal muscles and produce excitation of more superficial muscles, which may further alter tissue texture and quality of motion [57-58]. Chronic dysfunction is characterised by restricted range of motion, thickened tissues, and relatively little localised pain or tenderness at the site of dysfunction. Following acute injury (and probably ongoing repetitive trauma due to deficiencies in proprioception, motor control, and stabilisation), degenerative changes occur in the intervertebral disc and zygapophysial facet joints, periarticular connective tissue undergoes proliferation and shortening, and these degenerative changes act as co-morbid conditions that continue to affect the spinal unit. Sensitised nociceptive pathways may interfere with proprioceptive processing, creating deficits in proprioception and affecting segmental muscle control, which may disrupt the dynamic stability of the segment and predispose it to ongoing mechanical strain [57-58]. It has been purported that intervertebral joint dysfunctions are characterized by a reduction of mobility of a spinal segment, and that spinal manipulation can potentially affect the mobility of the joint, resulting in alterations of the kinematic behaviour of the spine. If treatment is precise, the spinal manipulative procedure should affect the mobility of the hypo mobile joint and lead to an increased range of motion at that particular segment [56]. However, Clements *et al* found that HVLAT manipulation of the atlantoaxial joint produced a significant immediate amelioration of passive atlantoaxial rotation asymmetry regardless of whether the HVLAT technique was applied unilaterally, either toward or away the restricted rotation, or bilaterally. Moreover, we also found that the increase in cervical range of motion after the manipulative procedure did not depend on the side of the manipulation. Therefore, it could be that HVLAT thrust has inherent qualities that can alter the cervical biomechanics, independently of the side and direction of the thrust. It is possible that experienced symptomatic improvement after HVLAT thrust also influences the range of motion improvement. In that way, it is possible that the effects of pain modulation rather than direct range of motion effects can lead to the changes in active range of motion [59]. The

neurophysiologic mechanisms by which spinal manipulative therapy is effective in reducing pain are not completely understood. One possible mechanism can be that the mechanical stimulation of joint capsule proprioceptors and muscle spindles, caused by the spinal manipulation, may induce a reflex inhibition of pain, reflex muscle relaxation, and improve mobility [60, 61]. Pickar demonstrated that spinal manipulation modifies the discharge of groups I and II (Proprioceptive) afferent [62]. Another mechanism might be that the afferent bombardment from joint and myofascial receptors provoked by the manipulative procedure can produce presynaptic inhibition of segmental pain pathways and possibly activation of the endogenous opiate system. After an extensive review of neurophysiologic effects of spinal manipulative therapy, Pickar concluded that more than one mechanism likely explains the effects of spinal manipulation. However, we cannot completely exclude a placebo effect by pure fact to put the therapists' hand on the symptomatic area. MET may influence pain mechanisms and promote hypoalgesia. Studies suggest MET and related post-isometric techniques reduce pain and discomfort when applied to the spine or muscles [63]. The mechanisms are not known, but may involve central and peripheral modulatory mechanisms, such as activation of muscle and joint mechanoreceptors that involve centrally mediated pathways, like the periaqueductal grey (PAG) in the midbrain, or non-opioid serotonergic and noradrenergic descending inhibitory pathways. Additionally, MET may increase fluid drainage and augment hypoalgesia. Rhythmic muscle contraction increases muscle blood and lymph flow rates, and mechanical forces acting on fibroblasts in connective tissues change interstitial pressure and increase trans-capillary blood flow. MET application may reduce pro-inflammatory cytokines and desensitize peripheral nociceptors [63]. For segmental dysfunctions that suggest a chronic condition, the most beneficial techniques may be those that stretch and mobilise tissues and improve proprioception and motor control. When applying MET to a chronic and restricted joint, engaging the barrier at the point of elastic end-range (rather than the first barrier) will load and stretch the shortened capsule and peri-capsular structures to produce viscoelastic and possibly plastic changes. Provided the localisation is maintained, more moderate contraction forces can be used to enhance post-isometric hypoalgesia and stretch tolerance and allow adequate post-contraction loading on the tissues. Isometric contraction will help Proprioceptive feedback and recruitment, but controlled isotonic (eccentric) contraction allowing the muscle to shorten over the range of motion may also be beneficial [63]. Our study demonstrated statistically significant improvements in disability following intervention ($P<0.05$). The reduction in mean NDI scores was 74.96% and 31.93% in the experimental group and control group respectively. Overall improvement in NDI scores was more in the experimental group than control group. Similarly we found larger effect size (d= 8.8) in experimental group than control group (d= 2.1). Vernon and Mior 55 reported that a minimum detectable change of 5 points or 10% is required to achieve clinical significance with this outcome measure. The improvement seen in both the groups was greater than 10% suggesting the change was not just statistically significant but clinically relevant. Our study revealed statistically significant improvements in PSFS scores following intervention ($P<0.05$). The improvement in the mean PSFS scores was 6.4 and 7.0 for the experimental and control group respectively. However these changes were more evident in the control group as compared to the experimental group. We found in our study that reading was a common activity while measuring PSFS scores in both the groups. Although the effect size was large in both the groups, but scores were found to be on the higher side in the control group. In summary, the current study analysed the effects of a combination of treatment (HVLAT manipulation and muscle energy techniques) versus muscle energy techniques alone in subjects with chronic neck pain. On the basis of our findings, the experimental group consisting of combination of treatment yielded better results as compared to the control group in outcome parameters like pain, range of motion and disability, whereas control group showed better results in terms of patient specific functions.

Conclusion

The present study shows that HVLAT when combined with MET is more effective to reduce pain intensity, to improve in cervical active ROM, to improve NDI score and to improve PSFS score in subjects with chronic neck pain as compared to M*Et al*one.

Limitation of Study

Although our study shows that when HVLAT was combined with muscle energy techniques, there was improvement in cervical range of motion and pain intensity, there are limitations to this study. The sample size of our study was small; blinding was not done in between subjects and therapist, study was short term (single session), i.e, we only examined the short-term effects of spinal manipulative therapy and muscle energy techniques directed at the cervical spine. A longer period of training could have shown better results in the outcome measures. Also, our study included a heterogeneous group which consisted of both females and males.

Further Scope of Study

- A larger sample size can be taken in further studies.
- Further studies can be done using a homogenous group.
- A long term follow up of patients can be done in further studies.
- In further studies a multimodal approach of treatment can be used for treatment of subjects with chronic neck pain.

Competing Interests: None

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