Effect of lower trapezius and serratus anterior muscle strengthening on pain and function in patients with chronic mechanical neck pain

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Effect of Lower Trapezius and Serratus Anterior Muscle Strengthening on Pain and Function in Patients with Chronic Mechanical Neck Pain

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Abstract: ***Background**: Neck pain is considered to be a very frequent and disabling complaint among the general population. **Purpose**: To study the effect of strength training of Lower Trapezius and Serratus Anterior muscles on pain and function in patients with chronic mechanical neck pain. **Method**: 24 chronic mechanical neck pain samples (12 experimental and 12 control groups)participated.The pre and post-assessment was done with Numerical Rating Scale (NRS), Algometer, Push-Pull Dynamometer and Neck Disability Index Scale (NDI)for Pain, Pain Pressure Threshold (PPT), Muscle Strength and Function respectively. The experimental group was given strength training along with conventional physiotherapy whereas the control group underwent only conventional physiotherapy. **Results**: The results showed a statistically significant difference in PPT (p value: 0.04), Lower Trapezius strength (p value: 0.02), Serratus Anterior strength(p value: 0.003) and NDI (p value: 0.04). **Conclusion**: Strength training for Lower Trapezius and Serratus Anterior muscles along with conventional physiotherapy should be incorporated in treatment of Chronic Mechanical Neck pain patients.*

Keywords: Chronic mechanical neck pain, Lower Trapezius, Serratus Anterior, Strength Training

1. Introduction

Neck pain has become a common complaint in office workers especially those engaged in sedentary occupations characterized by intensive computer use. [1]It affects 30% to 50% of the general population in any given year[2]having a point prevalence of nearly 13% and a lifetime prevalence of 50%. [3]Prevalence of neck pain is highest in the age group of 25-45 years as well as among women, manual workers and other ethnic groups[4]. It affects occupational and avocational activities of daily living as well as quality of life which ultimately leads to a high level of morbidity. [5]

Chronic pain is pain which lasts for more than 3 to 6 months. Chronic neck pain is characterized by a widespread sensation of hyperalgesia in the muscles and ligaments during active as well as passive movements.[1]It is usually known to be caused due to mechanical dysfunction of the cervical spine.[6]According to International Association for the Study of Pain (IASP), clinical features of neck pain include pain and stiffness in the neck, headache, dizziness and radiating pain to the shoulders and upper limbs. Clinical findings include decreased range of cervical movement, increased fatigability and decreased pain pressure thresholds of cervical muscles.[7]

The activity of the trapezius and serratus anterior muscles which are the main stabilizers of the scapula depends upon force production, neuromuscular control and recruitment which in turn require coordinated activities occurring at the right moment, creating the right amount of force and maintained for the right length of time. This precise firing pattern and recruitment requires the serratus anterior muscles to couple with upper, middle and lower trapezius resulting in 'force couples'. These force couples are necessary for normal scapular orientation [8,9,10]with arms by the side and in all upper limb movements.[11]In accordance with this, altered orientation of the scapula is usually caused by altered activity or poor neuromuscular control of the muscle segments mainly the trapezius and serratus anterior muscles.[11] Biomechanical reasoning indicates that altered axioscapular muscle activation associated with altered scapular orientation may induce increased load on the cervical spine.[12,13,14]

Also, recent studies have shown that neck and shoulder pain are likely to be caused by excess activation of Upper Trapezius combined with decreased control of Lower Trapezius and Serratus Anterior muscles.[1]According to another study performed by Sally Wegner et al, there is altered trapezius muscle activity in neck pain patients.[15] Supporting this, mechanical neck pain patients are likely to have a good Upper Trapezius muscle activity and decreased activity of Lower Trapezius and Serratus Anterior Muscles.

To the author's best knowledge most of the studies have concentrated on studying the scapular muscles as a whole and not the Lower Trapezius and Serratus Anterior muscles exclusively. Therefore, the purpose of our study is to find the effect of strengthening of Lower Trapezius and Serratus Anterior muscles along with conventional therapy protocol in chronic mechanical neck pain patients.

2. Review of Literature

1) Scapular muscle activity from selected strengthening exercises performed at low and high intensities.

Study was performed by Christoffer H. Andersen, Mette K Zebis et al at Copenhagen, Denmark. It determined scapular muscle activity during strengthening exercises for scapular muscles at low and high intensities (Borg CR10 levels 3 and 8). Surface EMG from selected scapular muscles was recorded during 7 strengthening exercises and expressed as percentage of the maximal EMG. Seventeen women aged 24-55 years without serious disorders participated. Press-up, prone flexion, one-arm row, and prone abduction at Borg 3and press up, push-up plus, and one-arm row at Borg 8- predominantly activated the serratus anterior over the lower trapezius. The middle trapezius was activated over the upper trapezius by one-arm row and prone abduction. Only the press-up and push-up plus activated both the lower trapezius and serratus anterior muscles over the upper trapezius. In conclusion, several of the investigated exercises both at low and high intensities activated the serratus anterior and lower and middle trapezius muscles, respectively over the upper trapezius muscle.

2) Lower trapezius and serratus anterior activation: which exercise to use for scapular neuromuscular reeducation?

Gonçalves Barreto, Rodrigo Py et al did a study on Low levels of activation of serratus anterior(SA) and lower trapezius (LT) muscles which are associated with kinematic dysfunctions of the scapular belt, for which the focus of functional recovery is neuromuscular reeducation. Hence, the proposed exercises were assumed to keep muscular activation at levels between 20% and 40% of the maximal voluntary contraction. Activation of SA and LT muscles were compared in different exercises by using surface electromyography which included modified crucifix, scaption, modified military press, pull over and low row, by ten healthy subjects. The highest SA activation was found during scaption, and the adequate activation of SA occurred during modified military press. The highest LT activation was seen in scaption and low row exercises. The exercises which kept the recommended activation range for neuromuscular reeducation for SA were the modified military press and scaption and low row for LT.

3) Influence of frequency and duration of strength training for effective management of neck and shoulder pain: a randomized controlled trial

This study was performed byChristoffer H Andersen, Lars L Andersen et al. A total of 447 office workers with and without neck and/or shoulder pain were randomly allocated at the cluster-level to one of the four groups: 1x60 (1WS), 3x20 (3WS) OR 9x7 (9WS) min a week of supervised high intensity strength training for 20 weeks, or to a reference group without training. Primary outcome measures were self-reported neck and shoulder pain scale (0-9) and secondary outcome measure was DASH (Disability in Arms Shoulders and Hands). The results showed reduced neck and right shoulder pain in the training groups after 20 weeks compared with reference group. All 3 training groups achieved significant pain reduction in the neck compared with reference group ($p<0.01$). From a baseline pain rating of 3.2 (SD 2.3) in the neck among neck cases, 1WS experienced a reduction of 1.14, 3WS 1.88 and 9WS 1.35 which is considered clinically significant. DASH was reduced in 1WS and 3WS only.

4) Establishing normative data of scapulothoracic musculature using handheld dynamometry

Nichole Turner, Kristen Ferguson et al did a study to establish normative data on the scapulothoracic musculature in normal subjects using a handheld dynamometer. 172 subjects with varying levels of overhead activity were chosen. A handheld dynamometer was used to test the upper, middle and lower trapezius, rhomboids and serratus anterior muscles. A 2 factor ANOVA was performed for each of the muscles. The results showed that activity levels did not significantly affect the unilateral ratios.

5) Physical exercises and functional rehabilitation for the management of chronic neck pain

This study was performed by J. Ylinen to reassess the effectiveness of different exercise methods in relieving pain and improving disability in patients with chronic nonspecific neck pain. Ten randomized controlled or comparative high-quality trials were included using the following outcome measures- patient's rated pain and disability as well as pain pressure threshold and neck strength and range of motion. Results revealed moderate evidence supporting the effectiveness of both long-term dynamic as well as isometric resistance exercises of neck and shoulder for chronic or frequent neck disorders.

3. Objectives

1) To assess the strength of Lower Trapezius and Serratus Anterior muscles among mechanical neck pain patients.
2) To study the effect of strengthening of Lower Trapezius and Serratus Anterior along with conventional physiotherapy versus only conventional physiotherapy among chronic mechanical neck pain patients.

4. Materials and Methodology

The population of this study included 24 chronic mechanical neck pain subjects. The experimental design was selected for this study. Convenient sampling technique was used to collect the 24 samples for the present study and the samples were then allocated to experimental as well as control groups equally on a random basis. The materials used included a Numerical Rating Scale, Algometer, Push-pull Dynamometer and Neck Disability Index scale to assess the pain, muscle strength and function respectively. Pre as well as post-assessment was conducted for the given parameters.

Inclusion Criteria

Subjects were included based on the criteria given by Grieve for mechanical neck pain. The criteria included (1) Local chronic cervical pain with or without arm pain (2) Juxtaposition of hypo and hyper mobile segmemts of the cervical spine due to spondylitic changes (3) Asymmetrical neck pain that gets worse as the day progresses and is aggravated by specific activities (4) Unilateral occipital pain and neck pain (5) Restricted and painful movements, especially rotation and lateral flexion to the painful side (6) Prominent Levator Scapulae and Upper and Middle Trapezius muscle (7) patients with unilateral radiculitis. [16]

Exclusion Criteria

Subjects were excluded if they had tendonitis, adhesive capsulitis, shoulder instability or impingement, previous trauma, whiplash injuries, cervical spine disc pathology, severe disorders of the cervical spine, post-operative conditions in the neck and shoulder regions or any neurological deficit.

Duration

The study was conducted for a period of 4-5 months.

Methodology

The study methodology was approved by the departmental ethics committee and was carried out at D.Y. Patil Hospital and Research Centre. The subjects were explained about the procedure and consent was taken for the same. Thereafter, they were evaluated with a pre-assessment for pain, pain pressure threshold, strength and function. The Numerical Rating Scale (NRS) on rest as well as activity for each of the participants was noted down. The subjects were asked to indicate the intensity of pain on a scale of 0 (no pain) to 10 (worst pain imaginable). [17] The pain pressure threshold was assessed with the help of an algometer. The subject was asked to sit on a chair or a plinth in a comfortable position. The neck was then palpated for the most tender area and continuous pressure was applied to the area with the help of an algometer approximately at a rate of 1kg/cm^2/seg. The pain pressure threshold was expressed in kg/cm^2. Three consecutive readings were taken and the mean was calculated for the same. Pain pressure thresholds lower than 3kg were considered abnormal. [18] The muscle strength of 4 muscles that is Upper, Middle, Lower trapezius and Serratus Anterior was assessed with the help of a Push-Pull dynamometer according to the procedure given by Nichole Turner et al.[19] Lastly, the subjects were asked to fill a 5-point Neck Disability Index scale (NDI) and the score for each of the subjects was converted into percent NDI. NDI is a patient completed, condition-specific functional status questionnaire. It includes 10 items such as pain, personal care, lifting, reading, headaches, concentration, work, driving, sleeping and recreation. For each section the total possible score is 5: if the first statement is marked, the section score is 0, if the last statement is marked it is 5. The total possible score is 50.[20] The experimental group received ultrasound, conventional physiotherapy and strength training whereas the control group received ultrasound and conventional physiotherapy which included neck isometric exercises such as static flexors, static extensors, static rotators and chin retractions. The strengthening program included 6 exercises specific to the lower trapezius and serratus anterior muscles. For lower trapezius- Prone Abduction, Prone Flexion and Low –row exercises were given whereas for serratus anterior- Modified Military Press, Shoulder Press and Scaption exercises were given. Before the start of the strengthening program, 1RM for each of the subjects of the experimental group was noted down. Dumbbells were used as a part of strength training. Two sets of five repetitions were given for each of the six different exercises, with a rest period of at least one minute between every new exercise or until the subjects had considered themselves able to continue.[21] The intervention program for control as well as experimental groups was carried out for 5 weeks (2 times per week) under complete supervision. After 5 weeks, the post-assessment for pain pressure threshold, strength, pain and function for each of the subjects was noted down. The data collected was then used for statistical analysis.

5. Results

The data was entered in a master sheet for tabulation and statistical analysis. The analyzed data has been organized and presented under the following headings:

Table I: Comparison of Pre-assessment versus Post-assessment of Numerical Rating Scale (NRS), Pain Pressure Threshold (PPT), Muscle Strength and Neck Disability Index (NDI) within the experimental group subjects.

Table II: Comparison of Pre-assessment versus Post-assessment of Numerical Rating Scale (NRS), Pain Pressure Threshold (PPT), Muscle Strength and Neck Disability Index (NDI)within the control group subjects.

Table III: Comparison of post-assessment of Numerical Rating Scale (NRS), Pain Pressure Threshold (PPT), Muscle Strength and Neck Disability Index (NDI)between experimental and control group subjects.

Table I: Comparison of Pre-assessment versus Post-assessment of NRS, PPT, Muscle Strength and NDI within the experimental group subjects

	Mean± S.D	95% confidence interval for mean		P value	Significance	Test Used
		Lower Bound	Upper Bound			
Pre NRS on rest	2.5			0.007	Very significant	Wilcoxon Signed Rank Test
Post NRS on rest	1					
Pre NRS on activity	6.79			0.002	Very significant	Wilcoxon Signed Rank Test
Post NRS on activity	4.41					
Pre PPT	2.35±0.55	-0.53	-0.31	0.00	Very significant	Paired T-Test
Post PPT	2.77±0.47					
Pre muscle strength-UT	15.05±3.06	-.42647	-.01353	0.03	Significant	Paired T-Test
Post muscle strength-UT	15.27±3.04					
Pre muscle strength-MT	13.15±2.75	-.19473	.07306	0.3	Not significant	Paired T-Test
Post muscle strength-MT	13.21±2.64					
Pre muscle strength-LT	11.97±1.70	-3.45055	-2.15612	0.00	Very significant	Paired T-Test
Post muscle strength-LT	14.77±1.12					
Pre muscle strength-SA	12.19±1.45	-2.03839	-10.459	0.00	Very significant	Paired T-Test
Post muscle strength-SA	14.77±1.19					
Pre NDI	14.83			0.002	Very Significant	Wilcoxon Signed Rank Test
Post NDI	10					

**** UT – upper trapezius, MT – middle trapezius, LT – lower trapezius, SA – serratus anterior***

Table II: Comparison of Pre-assessment versus Post-assessment of NRS, PPT, Muscle Strength and NDI within the control group subjects.

	Mean± S.D	95% confidence interval for mean		P value	Significance	Test Used
		Lower Bound	Upper Bound			
Pre NRS on rest	2.25			0.023	Significant	Wilcoxon Signed Rank Test
Post NRS on rest	1.58					
Pre NRS on activity	5.25			0.008	Very significant	Wilcoxon Signed Rank Test
Post NRS on activity	4.41					
Pre PPT	2.24±0.39	-.17805	-.07362	0.00	Very significant	Paired T-Test
Post PPT	2.37±0.41					
Pre muscle strength-UT	16.16±2.11	-.18152	.18152	1.00	Not significant	Paired T-Test
Post muscle strength-UT	16.16±1.99					
Pre muscle strength-MT	14.55±2.08	-.27530	.05364	0.16	Not significant	Paired T-Test
Post muscle strength-MT	14.66±2.20					
Pre muscle strength-LT	13.49±1.27	-.36003	.02503	0.08	Not significant	Paired T-Test
Post muscle strength-LT	13.66±1.15					
Pre muscle strength-SA	12.99±1.22	-.27530	.05364	0.16	Not significant	Paired T-Test
Post muscle strength-SA	13.10±1.28					
Pre NDI	11.16			0.043	Significant	Wilcoxon Signed Rank Test
Post NDI	11					

***** *UT – upper trapezius, MT – middle trapezius, LT – lower trapezius, SA – serratus anterior***

Table 3: Comparison of post-assessment of NRS, PPT, Muscle Strength and NDI between experimental and control group subjects

	Group	Mean± S.D	95% confidence interval for mean		P value	Significance	Test Used
			Lower Bound	Upper Bound			
NRS on rest	Experimental	1			0.22	Not Significant	Mann-Whitney U Test
	Control	1.58					
NRS on activity	Experimental	4.41			0.9	Not Significant	Mann-Whitney U Test
	Control	4.41					
PPT	Experimental	2.77±0.47	.01996	.77838	0.04	Significant	Unpaired T-Test
	Control	2.37±0.41					
Muscle Strength-UT	Experimental	15.27±3.04	-3.06616	1.28783	0.4	Not significant	Unpaired T-Test
	Control	16.16±1.99					
Muscle Strength-MT	Experimental	13.21±2.64	-3.50700	.61700	0.1	Not significant	Unpaired T-Test
	Control	14.66±2.20					
Muscle Strength-LT	Experimental	14.77±1.12	.14306	2.07694	0.02	Significant	Unpaired T-Test
	Control	13.66±1.15					
Muscle Strength-SA	Experimental	14.77±1.19	.61712	2.71788	0.003	Very significant	Unpaired T-Test
	Control	13.1±1.28					
NDI	Experimental	10			0.042	Significant	Mann-Whitney U Test
	Control	11					

***** *UT – upper trapezius, MT – middle trapezius, LT – lower trapezius, SA – serratus anterior***

Table I indicates that there was a statistically significant reduction in the post-assessment values of NRS (On rest and activity) and NDI whereas a statistically significant increase in the PPT as well as Upper and Lower Trapezius and Serratus Anterior muscle strength as compared to the pre-assessment following the intervention program in the experimental group subjects.

Table II indicates that there was a statistically significant decrease in the post-assessment values of NRS (On rest and activity) and NDI, whereas a statistically significant increase in PPT as compared to the pre-assessment following the intervention program in the control group subjects.

Table III indicates that there was a statistically significant decrease in the post-assessment values of NDI, whereas a statistically significant increase in PPT and Lower Trapezius and Serratus Anterior muscle strengths in the experimental group subjects as compared to the control group following the intervention program.

6. Discussion

The probable reasons for the decrease in NRS and NDI and increase in PPT as seen in**Table I** and **Table II** could be the use of ultrasound and conventional physiotherapy which included isometric exercises for experimental as well as control groups.

The ultrasonic wave is absorbed by the tissues and is then converted to heat by the tissues themselves. The thermal effects of ultrasound include an increase in metabolism which results in an over-all vasodilatation leading to increased output of waste products and increased supply of oxygen and nutrients to the damaged tissues. This leads to reduction of pain and accelerated healing of the tissues. Heat also causes stimulation of the sensory receptors in the nerve endings which ultimately leads to decreased transmission of pain through the pain gate. [22]Thus, the physiological effects of Ultrasound of increased blood flow, vascular permeability, and local metabolism and enhanced fibrous tissue extensibility and muscle relaxation help in reduction of pain and hence the NRS. [23]According to the Pain Gate mechanism, if a cutaneous stimulus of noxious type is applied such as Ultrasound, TENS, Hot packs, ice, it causes release of β endorphin which may be responsible for reduction of pain at a spinal level, as for the passage of pain through the gate, and there should be unopposed passage of nociceptive information at the substantia gelatinosa. However, if the gate is simultaneously receiving impulses produced by stimulating the thermoreceptors or mechanoreceptors (carried by large-diamter myelinated fibres), then there is presynaptic inhibition of the small–diameter nociceptive information and the gate is closed to nociceptive traffic. The descending neurons present in in the mid-brain may cause release of endogenous opiates into the substantia gelatinosa at the spinal cord level, causing inhibition of transmission in the nociceptive circuit synapses by blocking the release of a chemical transmitter (substance P) in the pain circuit.[22]

Isometric exercises also known as static exercises, involve muscular contractions without movement of the involved parts of the body in which the muscle contracts against a load which is fixed or immovable. According to Carrie M Hall et.al, isometric exercises help in increasing muscle performance. Although no joint movement occurs, they are considered functional because they provide a strength base for dynamic exercise. [24] The most widely considered mechanism for decrease in pain and increase in PPT due to exercise is that exercise causes activation of the endogenous opioid system which reduces the pain perception following exercise. Exercise of sufficient intensity and duration leads to release of peripheral and central beta-endorphins which have been associated with changes in pain sensitivity which in turn may be responsible for increase in PPT. [25] According to the study conducted by J Ylinen et al, specific moderate and high-intensity neck muscle training has shown to reduce neck pain, which was associated with reduced pressure pain sensitivity in the neck muscles, in turn helping in increasing the pain pressure threshold [26] which was also seen in our study.

According to **Table III**, the experimental group subjects showed an additional decrease in NRS and NDI, whereas an increase in Pain Pressure Threshold and Lower Trapezius and Serratus Anterior muscle strength as compared to the control group subjects.

The probable reasons for this could be the incorporation of strength training in the intervention program for the experimental group subjects.

Resistance training has been shown to improve the metabolism and induce an anabolic response in muscles which lead to increased protein synthesis, in turn, helping in decreasing the pain. [26] Dynamic exercises also have an advantage that there is an increased movement of the joint, resulting in capsular, ligament and muscular flexibility and increased cartilage nutrition which may help in better pain reduction. [24] Training effects include increased afferent nerve activity due to stimulation of the mechanoreceptors around the joints, may inhibit the activity of the small diameter pain nerves.[26] According to T. Graven-Nielsen et al, muscle pain reduces the maximal voluntary contraction of a muscle.[27] Therefore, following strength training, there may be a decrease in NRS which may lead to a decrease in muscle pain ultimately leading to an increase in maximal voluntary muscle contraction. Reduction of pain may also be due to modification in the environment of peripheral nociceptors following increased metabolism, healing and strengthening of the tissues in which the pain receptors lie. [26]

The continuous contraction of muscle fibres which occurs during repetitive work tasks, lead to high local energy turnover and therefore causes an increase in the intramuscular pressure around the fibres, in turn, reducing the blood flow to the muscle fibres requiring the most oxygen, decreasing the ATP production in the aerobic pathway, leading to accumulation of inorganic phosphate. This leads to a decrease in lactate outflow as blood flow decreases, increasing the lactate level ultimately promoting acidification of the muscles. This leads to diminished muscle contractility which ultimately lowers muscle function.[28]Patients with chronic mechanical neck pain have also shown to have decreased blood flow to the trapezius muscles. Also, due to immobility or decreased loading, myonuclear numbers decrease and protein turnover becomes negative that is catabolic. Both endurance and strength training have been found to help in increasing Na+-K+-pump concentration and also the number of capillaries in the trapezius muscles, possibly contributing to an improvement in the muscle strength. [26]

The main stabilizers of the scapula include Serratus Anterior, all three trapezius muscles, Rhomboids (major and minor) and Levator Scapulae. If there is weakness or imbalance of these muscles, it may lead to altered position of the scapula and may also decrease its stability. As a result of this, the function of the shoulder complex may become inefficient leading to a decrease in neuromuscular performance which may have been corrected by improving the strength of the Lower Trapezius and Serratus Anterior muscle as found in our study, thereby decreasing the load on the cervical and thoracic spine, resulting in a functionally more efficient muscle-joint complex. [24]

According to IASP, altered co-ordination of cervical muscles and impaired proprioception in the neck and shoulder may contribute to neck pain. Patients with chronic neck pain have also been found to usually suffer from sensorimotor impairment, leading to excessive strain and microtrauma. It has been hypothesized that resistance training can lead to increased sensitivity of the muscle spindles, Golgi tendon organs, and proprioceptors of joints.[26]

Improved function and decreased disability in patients with chronic mechanical neck pain has been proven to occur with intensive regular training which brings about an increase in the neck muscle strength and range of motion.[26] This is supported by the findings on NDI found in our study.

7. Conclusion

In this study, it was found that strength training for Lower Trapezius and Serratus Anterior muscles along with conventional physiotherapy showed better improvement on NRS, Pain Pressure Threshold and NDI for pain and function respectively as compared to only conventional physiotherapy.

8. Future Implications

Exercise protocols involving muscles of other force couples of the shoulderprescribed for chronic mechanical neck pain patients could be explored and compared with the force couple targeted in this study for better treatment efficiency.

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References

[1] Christopher H Andersen, Lars L Andersen, Ole S Mortensen, Mette K Zebis, Gisela Sjogaard. Protocol for shoulder function training reducing musculoskeletal pain in shoulder and neck: A randomized control trial. BMC Musculoskeletal Disorders, 2011.

[2] Adam P. Goode, Janet Freburger, Timothy Carey. Prevalence, Practice Patterns and Evidence for chronic neck pain. Arthritis Care and Research, 2010.

[3] Peter D Aker, Anita R Gross, Charles H Goldsmith, Paul Peloso. Conservative management of Mechanical Neck Pain: Systematic overview and meta-analysis. BMJ 1996;313:1291.

[4] Östergren P, Hanson BS, Balogh I, *et al*. Incidence of shoulder and neck pain in a working population: effect modification between mechanical and psychosocial exposures at work? Results from a one year follow up of the Malmö shoulder and neck study cohort. Journal of Epidemiology & Community Health 2005; 59: 721-728.

[5] Howard Vernon, Barry Kim Humphreys. Chronic mechanical neck pain in adults treated by manual therapy: A systematic review of change scores in randomized controlled trials of a single session. Journal of manual and manipulative therapy, 2008.

[6] Bogduk N, Aprill C. On the nature of neck pain, discography and cervical zygapophyseal joint blocks. Pain 1993; 54:213-217.

[7] International Association for the Study of Pain (IASP). Global Year Against Musculoskeletal Pain (2009-2010).

[8] Inman VT, Saunders M, Abbott LC. Observation of the function of the shoulder joint. ClinOrthopRelat Res 1996; 330: 3-12.

[9] Mottram SL. Dynamic stability of the scapula. Man Ther 1997; 2(3): 123-31.

[10] Kibler WB, McMullen J. Scapular dyskinesis and its relation to shoulder pain. J Am AcadOrthopSurg 2003; 11(2): 142-51.

[11] Comerford MJ, Mottram SL. Diagnosis of uncontrolled movement, subgroup classification and motor control retraining of the shoulder girdle. Ludlow, UK: KC International; 2010.

[12] Behrsin J, Maguire K. Levator scapulae action during shoulder movement: a possible mechanism for shoulder pain of cervical origin. Aust J Physiother 1986; 32(2): 101-6.

[13] Janda V. Muscles and motor control in cervicogenic disorders: Assessment and management. In: Grant R, editor. Physical Therapy of the cervical and thoracic spine, New York: Churchill Livingstone; 1994.

[14] Jull GA, Falla D, Treleaven J, Sterling M, O'Leary S. A therapeutic exercise approach for cervical disorders. Grieve's Modern Manual Therapy: The Vertebral Column. Churchill Livingstone, Elsevier science: Edinburgh, UK; 2004.

[15] Sally Wegner, Gwendolen Jull, Shaun O'Leary, Venerina Johnston. The effect of a scapular postural correction strategy on trapezius activity in patients with neck pain. Manual Therapy 2010; Volume 15: 562-566.

[16] Grieves criteria

[17] McCaffery, M., Beebe, A., et al; Pain: Clinical manual for nursing practice, 1989.

[18] Fischer AA, Pressure algometry over normal muscles: Standard values, validity and reproducibility of pressure threshold, Pain 1987; 30:115-126.

[19] Nichole Turner, Kristen Ferguson, Britney W. Mobley, Bryan Riemann and George Davies. Establishing normative data on scapulothoracic musculature using hand-held dynamometry. Journal of sport rehabilitation 2009; 502-520.

[20] NDI developed by: Vernon, H. &Mior, S. The Neck Disability Index: A study of reliability and validity, Journal of Manipulative and Physiological Therapeutics, 1991.

[21] Gonçalves Barreto. Lower trapezius and serratus anterior activation: which exercises to use for neuromuscular reeducation. ConScientiaeSaude 2012.

[22] E Bellis Clayton, Angela Forster and Nigel Palastanga. Clayton for Electrotherapy, 9th edition. London: Bailliere Tindall; 1985.

[23] PınarDorukAnalan, BerrinLeblebic and Mehmet Ada. Effects of therapeutic ultrasound and exercise on pain, function, and isokinetic shoulder rotator strength of patients with rotator cuff disease. The J Phys Ther Sci 2015; 27(10): 3113-3117.

[24] Carrie M Hall, Lori Thein Brody-Therapeutic Exercise Moving towards Function, 2nd edition, United kingdom, Zeefarm ltd 1980.

[25] Kelly M, Naugle, Roger B. Fillingim, and Joseph L. Riley. A meta-analytic review of the hypoalgesic effects of exercise. The journal of pain: official journal of The American Pain Society 2012.

[26] J. Ylinen, Physical exercises and functional rehabilitation for the management of chronic neck pain, Eura Medicophys 2007.

[27] Graven-Nielsen T, Lund H, Arendt-Nielsen L, et al.: Inhibition of maximal voluntary contraction force by

experimental muscle pain: a centrally mediated mechanism. Muscle Nerve 2002.
[28] Toshikazu Kubo, TetsushiMinamitani, Hiroyasu Nishikawa, Yasusuke Hirasawa. Effects of muscle blood flow on muscle energy metabolism and contractility. Pathophysiology 4, 1998; 303 – 308.

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