ISSN No:-2456-2165

The Effectiveness of Eccentric Exercise Training on Pain and Disability in Supraspinatus Tendinopathy in Adjunct to Conventional Physical Therapy: A Quasi-Experimental Study

[1]Bijish K Bhaskaran
Principal and Professor, PES College of Physiotherapy, Kuppam, Chittoor, Andhra Pradesh, India

[2]Dr. Mammen Thomas
Professor and HOD (Rtd), Department of Orthopaedics, Govt. Medical College Hospital, Thiruvananthapuram, Kerala, India

[3]S Pasupathy
Chief Physiotherapist (Rtd), Government Hospital, Chennai, Tamilnadu, India

[4]Nincy Thomas
Senior Physiotherapist, Sadhu Vaswani Mission's Medical Complex, Koregaon Park, Pune, Maharashtra, India

Abstract:-

➢ ***Background*:**
The management of tendinopathy with painful eccentric exercise training demonstrates good clinical results in patients with chronic Achilles tendinosis and Patellar tendonitis. The pain mechanism in Supraspinatus Tendinopathy (ST) have not been scientifically clarified, but the histo-pathological changes found in the supraspinatus tendon showed similarities with the findings of Achilles tendinosis.

➢ ***Aims:***
To find the effectiveness of Eccentric Exercise Training on pain and disability in Supraspinatus Tendinopathy when given in adjunct to Conventional Physical Therapy.

➢ ***Methods*:**
Sixty subjects (Age 20-40 years) were selected from the population by purposive sampling technique who were attending the physiotherapy department with right shoulder pain and met all the criteria. 30 subjects allotted to Group A, were given Conventional Physical Therapy for 6 days per week for four weeks and 30 subjects allotted to Group B, were given Eccentric Exercise Training, with 3 sets of 15 repetitions, twice a day, 6 days per week, for four weeks, adjunct to Conventional Physical Therapy. VAS and SPADI were the tools to evaluate pain and disability.

➢ ***Results*:**
t test was used for analysis. The mean difference and SD of VAS and SPADI for Group A and Group B were VAS (-1.8±0.43), SPADI (-16.12± 4.80) and VAS (-3.33± 0.66), SPADI (-26.23 ± 7.00) respectively. In comparison, of mean difference for VAS and SPADI between Group A and Group B were VAS with t value 2.585 ($P< 0.05$) and SPADI with t value 2.163 ($P< 0.05$).

➢ ***Conclusion*:**
The short term Eccentric Exercise Training adjunct to Conventional Physical Therapy but not with Conventional Physical therapy alone, significantly reduced pain and disability in Supraspinatus Tendinopathy.

Keywords:- *Shoulder; Supraspinatus Tendinopathy; Pain; Eccentric Exercise Training*

I. INTRODUCTION

The tendon injuries are acute and chronic, caused by the intrinsic and extrinsic factors. The overuse injuries generally have multifactorial origin. Excessive loading of tendons during vigorous physical training is regarded as the main pathological stimulus for degeneration and there may be a greater risk of excessive loading inducing tendinopathy in the presence of intrinsic risk factors. Tendon damages may occur due to stress within the physiological limits, as frequent cumulative microtrauma may not allow enough time to self repair. The microtrauma which results from the nonuniform stress, in the tendons and leads to abnormal load concentrations and frictional forces between the fibrils which causes the localized fiber to damage. Ischemia occurs when a tendon is under maximal tensile load, and on relaxation, reperfusion occurs, by generating the oxygen free radicals; this may cause the tendon to damage, resulting in tendinopathy.[1]

Tendons transmits force from muscles to bone and act as a buffer by absorbing external forces to limit muscle damage and also exhibits high mechanical strength, with good flexibility and the level of elasticity to perform their unique role. Tendons are viscoelastic tissues that displays stress, relaxation and creep.

The causes of supraspinatus tendinopathy can break down into extrinsic and intrinsic factors. Extrinsic factors can break down into primary impingement, which is a result of increased subacromial loading, trauma, overhead activity and secondary impingement, due to overloading of rotator cuff, shoulder muscle imbalance, glenohumeral joint laxity, scapular dyskinesia, posterior capsule tightness and trapezius paralysis. Intrinsic factors include acromial morphology, acromioclavicular arthrosis, coracoid impingement, thickening of subacromial bursae and fibrosis, impaired rotator cuff vascularity, aging, intratendinous, calcific tendinopathy, primary tendinopathy.[2]

Dynamic stability of the gleno-humeral joint is established by the balance of shearing and compressive forces. The rotator cuff mechanism contributes the dynamic support by compressing the surfaces of the gleno-humeral joint. The supraspinatus and the deltoid musculature are the dominant compressive contributors at 90º of abduction. The supraspinatus is felt to have a large role in initiating abduction. In early stages of gleno-humeral abduction the deltoid reactive force is located outside the glenoid fossa and the force is counteracted by the transverse compressive forces of the supraspinatus and infraspinatus. The angle of pull of the supraspinatus muscle is more constant at approximately 75º, acting not only to elevate or abduct the arm, but also to compress the humeral head in the glenoid fossa. The auxiliary function of the supraspinatus is to compress the glenohumeral joint and act as a vertical sterer for the humeral head.[3]

The role of exercise in managing tendinitis is manifold. First, there is a vascular effect whereby exercising the attached muscle produces a demand induced increase in blood flow, thereby assisting nutrition. Second, the tensile changes in an exercising tendon stimulate a pumping effect where by blood from the longitudinal vessels is decreased under tension and forced into radial vessels, and on relaxation of the muscle the reverse occurs. Third, the application of tensile force provides a stimulus for the newly laid collagen fibers to orient themselves along the longitudinal (load bearing) axis of the tendon (Oakes 1992). Fourth, exercise can be used to maintain the strength, power, endurance and co-ordination of the muscle as its tendon recovers.[4]

The application of eccentric exercise has been investigated by Curwin and Stanish (1985) and reported by them to be valuable in the management of a tendinitis resulting from a tensile overload. This applies for both overuse and traumatic lesions.[5]

Eccentric exercises are considered the greatest in strengthening programs, as the load on the muscle increases and it finally reaches a point where the external force of the muscle is beyond the force that the muscle can generate during loading. Thus, even though the muscle is fully activated, it is forced to lengthen due to the high external load. This is referred as eccentric contraction.[5]

Eccentric exercise is a type of static or dynamic muscle loading where tension in the muscle develops and physical lengthening of the muscle occurs when an external force is applied to the muscle. Eccentric muscle contractions involve negative work and also provide a source of shock absorption during closed-chain daily functional activities. In addition to an eccentric contraction having greater force producing capability than a concentric contraction, an eccentric contraction against a maximum load produces more tension than an isometric contraction. Further, there are few evidences to indicate that adaptive strength gains are greater at the conclusion of an eccentric program as compared to either a concentric or isometric training.[6]

Eccentric muscle loading consumes less oxygen and fewer energy stores than concentric muscle contractions against similar loads. The Metabolic energy cost is lower in eccentric exercise at comparable concentric workloads, with the same resistance, the lower EMG activity demonstrates that fewer motor units are recruited during an eccentric contraction to produce the same amount of force when compared to concentric contraction. Thus an individual requires less effort to control a load eccentrically than concentrically.[7]

Brett L Woodley, Richard J Newssham-West et al. (2007) had given a systemic review on chronic tendinopathy: effectiveness of eccentric exercise and concluded with the review which demonstrated the lack of high-quality research done in support of the clinical effectiveness of eccentric exercises over other treatments in the management of tendinopathies.[8]

Karsten Knobloch, Robert Kraemer et al. (2007) had done a study on eccentric training decreases paratendon capillary blood flow and preserves paratendon oxygen saturation in chronic Achilles tendinopathy and concluded that the study supports earlier findings that neo-vascularization plays an important role in tendinopathy and that exercises helps to reduce this abnormal development and may improve rates of healing.[9]

Per Jonsson, Per Wahlstrom et al. (2005) had done a study on "eccentric exercise training in chronic painful impingement syndrome of the shoulder on nine patients with long duration of shoulder pain which diagnosed as having shoulder impingement syndrome and were on waiting list for surgical management and concluded that painful eccentric training for supraspinatus is effective."[12]

Per Jonsson, H Alfredson et al. (2005) had done a study on "jumper's knee with eccentric compared to concentric quadriceps training on two groups with patellar tendinitis with 9 and 10 subjects, and were given concentric training and eccentric training respectively, for 12 weeks and concluded that eccentric training but not concentric quadriceps training on a decline board seemed to reduce pain in jumpers knee."[14]

Experimental hypothesis was that there will be significant difference of pain and disability in Supraspinatus Tendinopathy when Eccentric Exercise Training is given adjunct to Conventional Physical Therapy. The aim of this study was to find the effectiveness of eccentric exercise

training on pain and disability in supraspinatus tendinopathy, in adjunct to conventional physical therapy.

II. MATERIALS AND METHODS

The institutional ethical committee approval was obtained prior to study. The physiotherapists were trained for Eccentric exercise training. The 60 subjects were selected by purposive sampling technique who fulfilled the inclusion criteria. The subjects were randomly assigned to Group A Conventional Physical Therapy (CPT) and Group B Eccentric Exercise Training (EET) with 30 subjects each. The subjects were blinded and the physiotherapists, who collected data were also blinded.

Inclusion criteria: Subjects with Supraspinatus Tendinopathy as a result of repetitive overhead activities[3], Presented with localized pain and tenderness at anterolateral shoulder and pain in abduction, Jobe's test and Hawkins Kennedy test[36] positive, Right-sided Supraspinatus Tendinopathy, Duration: 10 days to 3 months, Subjects who had not undergone physical therapy previously.

Exclusion criteria: Bicipital tendinitis, Frozen shoulder, Subjects injected with corticosteroid in preceding six months, Inflammatory rheumatic disease with involvement of Shoulder, Direct trauma to shoulder, any previous fractures of humerus, clavicle, and acromion process, Cervical spondylosis with radiating pain in anterior shoulder, Arthropathies of acromio-clavicular joint.

Tool: Visual analogue scale (VAS)[30] and Shoulder Pain and disability Index (SPADI)[31]

Equipments used: Eccentric Training (Ulla – Sling, Pulleys, Rope, S hooks and Handle), Conventional Physical Therapy (Ultrasound unit (Calibrated),Gel, Cotton).

Figure No. 1: Ulla Sling, Rope, Pulley, S hooks, Handle

The pilot study was conducted on 20 subjects from the subjects selected, were allocated to Group A CPT (Control group) and Group B EET (Experimental group). Group A was given Conventional Physical Therapy and Group B was given Eccentric Exercise Training adjunct to Conventional Physical Therapy for four weeks with the same protocol of the main study. The subjects participated in pilot study were not included in the main study. Pain and Disability were evaluated by VAS and SPADI. On intragroup and intergroup analysis, the Group B has shown better results in reducing the level of pain and disability after treatment $P<0.05$ significantly.

Data collection: The subjects signed the consent forms and level of pain and disability was determined by using VAS and SPADI questionnaire from both the Group A and Group B. The Group A was treated with Conventional Physical Therapy and Group B was treated with Eccentric Exercise Training adjunct to Conventional Physical Therapy for 6 days per week for 4 weeks and the level of pain and disability was recorded on VAS and SPADI questionnaire on the 1st day and 28th day.

The Group A was given the Conventional physical therapy (CPT) with protocol, Ultrasound therapy (1 MHz, Pulsed, Intensity: 1 W/cm^2, Duration: 7 minutes. Shoulder range of motion exercises (3 sets of 10 repetitions each), Stretching (3 times with 30 seconds duration) and Codman's exercises (20 repetitions) for 6 days per week for four weeks.

Shoulder Range of Motion Exercises

Active Flexion, Active Abduction, Supine Internal and External rotation, Seated press up off a chair, Rowing Stretching of Anterior Musculature, Posterior Musculature: 3 times for 30 seconds.[30]

Codman's Exercises: Subjects were asked to lean over the couch, supporting the body with involved arm, and letting involved arm hang straight down in a relaxed position. The arms were gently swinged in circles clockwise and counter clockwise, and then in a pendular motion forward, backward and side to side with 20 repetitions each.[23]

Eccentric exercise training (EET) : The Group B was given Eccentric Exercise Training adjunct to Conventional Physical Therapy.

All the subjects were given practical instructions by the researcher prior to the start of the study. A special eccentric muscle-training model mainly activating the supraspinatus muscle was used which was specially designed by physiotherapist Per Jonsson (2005). A device called Ulla-Sling was attached to the roof, with pulley, rope, S-hooks, and handle, which was used to elevate the arm to the starting position. The eccentric training program was executed by having the patient to slowly lower the arm from the start position (horizontal abduction of shoulder with 30^o forward flexion and thumb pointing towards the ground), (Fig.2,3,4) and to the end position for eccentric exercise (Fig. 5), controlled by the opposite arm. This was done 3 sets of 15 repetitions, twice a day, 6 days per week for 4 weeks.[12]

Eccentric Exercise Training

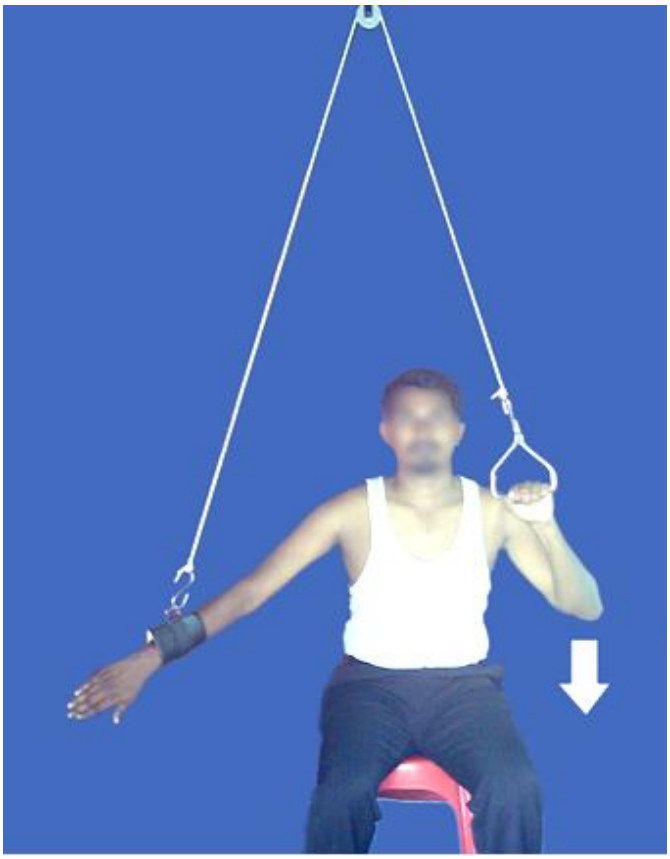

Figure No.2: Lifting Limb passively

Figure No.3: Starting Position (Empty Can)

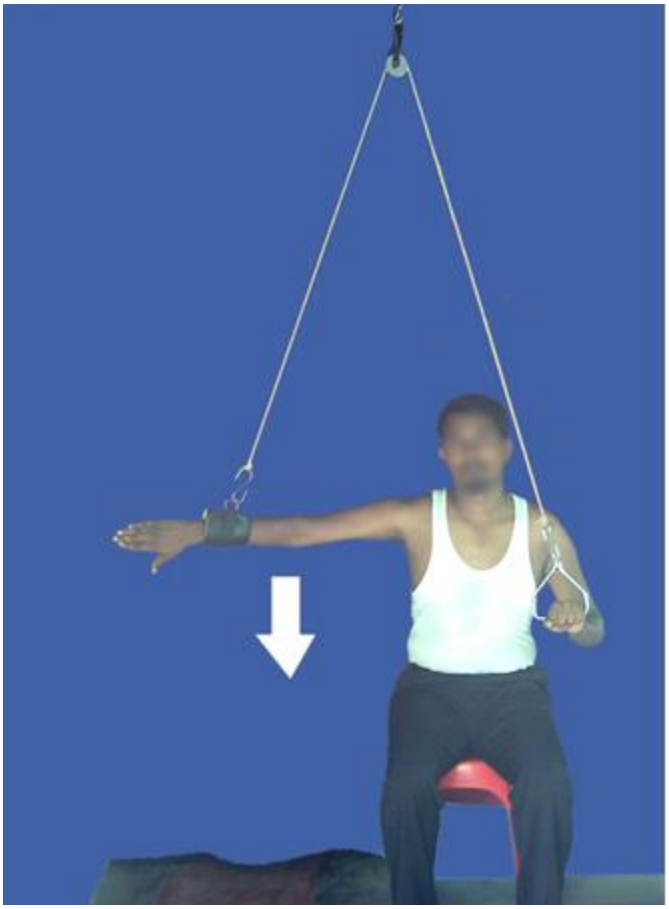

Figure No.4.: Lowering limb from starting position (Eccentric Exercise)

Figure No.5.: End Position

III. RESULTS

Intra group analysis

The paired t test was done to compare the mean value of VAS and SPADI at Pre and Post sessions within Group A and Group B, the values for Group A VAS t value 12.95 (P<0.05) and SPADI t value 18.37 (P<0.05) and for Group B, VAS t value 27.62 (P<0.05) and SPADI t value 18.09 (P<0.05) respectively and was statistically significant.

Intergroup analysis

The unpaired t test was done to compare the mean difference (post-pre) for VAS and SPADI between Group A and Group B were VAS t value 2.585 (P<0.05) and SPADI t value 2.163 (P<0.05) respectively and was statistically significant (Table 2)

The results showed that there were significant changes within the Group A and Group B and in intergroup analysis too. On comparing both Groups, the results were significant and Eccentric Exercise Training adjunct to Conventional Physical Therapy gave better results than Conventional Physical Therapy alone. Hence, Experimental hypothesis was accepted.

Inter Group Analysis

Group	VAS (A)	VAS (B)	SPADI (A)	SPADI (B)
Mean	5.1	3.97	48.5907	42.0827
SD	1.83	1.4016	14.3455	7.9976

Table 1: Mean and SD of VAS and SPADI for Group A and Group B

SESSION	GROUP A MEAN		GROUP B MEAN	
	VAS	SPADI	VAS	SPADI
POST-PRE (Mean)	-1.9	-16.12	-3.33	-26.70

Table 2: Mean difference (Post – Pre) and SD of VAS and SPADI for Group A and Group B

IV. DISCUSSION

The application of eccentric exercises has been investigated by Curwin and Stanish (1985) and reported by them to be valuable in the management of tendinitis resulting from a tensile overload, applies for both overuse and traumatic lesions. Per Jonsson (2005) had done a pilot study on eccentric training in chronic shoulder impingement syndrome after he found histological examination similarities with Achilles tendinosis on supraspinatus tendon in impingement syndrome. Before this study, he had done eccentric training in the management of Achilles tendon and in jumpers knee, which was found to be effective. The findings of the above studies, led to do this study on effectiveness of eccentric exercise training in supraspinatus tendinopathy with a shorter duration.

The present study was conducted on a sample size of sixty subjects. The sample size was divided into two groups in which one group was given C P T and another was given E E T adjunct to C P T. Two patients dropped out due to inconvenience after three weeks. The drop out subjects were also included in the data analysis The results were interesting and satisfactory to all patients.

The present study suggested that C P T and E E T when given adjunct to C P T reduced the pain and disability level after the treatment (P < 0.05) significantly, in intra group analysis.

The inter group analysis showed that the Group B is more effective than Group A in reducing the pain and disability level and which is significant at P<0.05, thus the experimental hypothesis were retained.

Gotoh et al. (1998) has suggested the subacromial bursa as the site for pain, with presence of high amounts of substance P nerve fibres, localised around vessels[37]. Alfredson H et al. (2003) stated that interesting recent scientific studies on chronic painful Achilles tendinosis have demonstrated vasculo-neural ingrowth as being the most likely source of pain in Achilles tendinosis[18] and Ohberg L et al. (2003) stated that good clinical results after treatment with eccentric exercises in calf muscle training were associated with the lack of remaining neo vessels.[20] Chansky and Iannoti (1991) also found neo vascularization to be associated with the symptomatic rotator cuff disease, secondary to mechanical impingement.[38]

In this study, painful eccentric exercise training was used on patients with Supraspinatus Tendinopathy. Previous studies had emphasized in pain free training during a shoulder rehabilitation to strengthen the depressor muscles. Some studies, also has recommended that patients should avoid a position of shoulder in long lever, as the supraspinatus muscle activity has been demonstrated to be high, when the arm is in the extended and abducted position in scapular plane. Few studies have recommended that instead of using full can (external rotation) position during supraspinatus muscle training, empty can (internal rotation) position should be used, because empty can position increases the sub-acromial space as the greater tuberosity clears the under surface of the acromion process. In this study the test position was chosen to perform the eccentric training in empty can position that decreases the sub acromial space and placed maximum load on the supraspinatus muscle. Previous studies have shown good and promising results with painful eccentric exercise training on other chronic painful tendon conditions.

The exact mechanisms for achieving good results with eccentric exercise training are not clearly understood. It is assumed it might be due to an effect of lengthening of the musculo-tendinous system and thereby less tendon loading and leads to less tendon pain, and also it might be that the exercises induce an alteration in the metabolic events involved in generating pain mechanisms in the tendon. Another possible explanation in a few studies for the differences in the results, may be due to eccentric loading is

associated with a better tissue response in terms of tissue repair mechanisms.

These finally supported by the studies like, Per Wahlstrom et al. (2005) have done a study on eccentric exrcise training in chronic painful impingement syndrome of the shoulder, on nine patients with a long duration of shoulder pain, diagnosed as having shoulder impingement syndrome and were on waiting list for surgical management for 12 weeks and concluded that painful eccentric exercise training for supraspinatus is effective.[12]

Per Jonsson et al. (2003) have done a study on chronic Achilles tendon pain treated with eccentric calf-muscle training on two groups with chronic painful mid-portion Achilles tendinosis and chronic insertional Achilles tendon pain on 101 subjects and 31 subjects respectively for 12 weeks and concluded that the management with eccentric exercise calf-muscle training, produced good clinical results in patients with chronic painful mid-portion Achilles tendinosis.[17]

Robert Kraemer et al. (2007) have done a study on eccentric exercise training, which decreases paratendon capillary blood flow and preserves paratendon oxygen saturation in chronic achilles tendinopathy on twenty patients with three months duration for a period for twelve weeks and concluded that the study supports earlier findings that neo-vascularization plays an important role in tendinopathy and that eccentric exercises helps to reduce this abnormal development and may improve rate of healing.[9]

Aspelin et al. (2004) had done a study on eccentric exercise training of the gastrocnemius-soleus complex in chronic Achilles tendinopathy which results in decreased tendon volume and intratendinous signal, as evaluated by MRI on twenty five patients before and after eccentric training for three months and concluded that eccentric training resulted in decreased tendon volume and intratendinous signal and was correlated with an improved clinical outcome.[16]

The following researcher does not support the eccentric exercise training in patellar tendinopathy, Havard Visnes et al. (2005) had done a randomized clinical trial, on no effect of eccentric exercise training on jumper's knee among volley ball players during the competitive season, on twenty nine players with patellar tendinopathy, with twelve weeks intervention period and concluded that there was no effect on knee function from a twelve week eccentric exercise intervention programme, among a group of volleyball players having patellar tendinopathy, with continuing to train and compete during the treatment period.

As the exercises for tendonitis brings vascular effect produces a demand induced increase in blood flow in assisting nutrition, the tensile changes in an exercising tendon stimulates a pumping effect whereby blood from the longitudinal vessels is decreased under tension and forced into radial vessels and on relaxation of the muscle, the reverse occurs, the application of tensile force provides a stimulus for newly laid collagen fibres to orient themselves along the longitudinal axis of tendon (Oakes 1992) and exercise can be used to maintain the strength, power, endurance and co-ordination of the muscle as its tendon recovers. Thus Eccentric Exercise Training plays a vital role in Supraspinatus tendinopathy and can be used as the treatment model adjunct to other physical therapy treatment models.

V. LIMITATIONS OF THE STUDY

There was no follow up of the patients after three months and six months, small sample size, skewed distribution between male and female made difficult to generalize the scores, and there was no weekly recording of outcome measures.

VI. CONCLUSION

The short term Eccentric Exercise Training adjunct to Conventional Physical Therapy but not with Conventional Physical Therapy alone, significantly reduced pain and disability in Supraspinatus Tendinopathy.

REFERENCES

[1]. Pankaj Sharma, Nicola Maffulli, et al. Tendon injury and Tendinopathy: Healing and Repair, The Journal of Bone and Joint Surgery. Am 2005; 87:187-202.
[2]. Thomas M De Berardino, MD, Wing K Chang MD. Supraspinatus Tendonitis, e Medicine Specialities.Nov.2006.
[3]. Robert A Donatelli PhD, PT.O.C.S, Physical therapy of the shoulder, 3rd edition. Churchill Livingstone; 1997.p.236-237, 396-397.
[4]. Nordin Frankel, Basic Biomechanics of the musculoskeletal system.3rd edition. Lippincott William and Wilkins; 2001.p.318-339.
[5]. Maria Zuluaga, Christopher Briggs, et al. Sports Physiotherapy, 1st edition.Churchill Livingstone;1995.p.396.
[6]. Muscle physiology types of contractions. National Skeletal muscle research centre www.muscle.ucsd.edu
[7]. Carolyn Kisner MS PT, Lynn Allen Colby.MS PT, Therapeutic Exercises Foundations and Techniques, 3rd edition. Jaypee brothers; 2003.p.69-71.
[8]. Brett L Woodley, G David Baxter, et al. Chronic Tendinopathy: effectiveness of eccentric exercises. British Journal of Sports Medicine 2007; 41:188-198.
[9]. Karsten Knobloch, Robert Kraemer, et al. Eccentric Training Decreases Paratendon Capillary Blood Flow and Preserves Paratendon Oxygen Saturation in Chronic Achilles Tendinopathy. Journal of Orthopaedic and Sport Physical Therapy 2007; 37-5:269-276.
[10]. Karsten Knobloch, Eeccentric training in Achilles tendinopathy: is it harmful to tendon microcirculation? British Journal of Sports Medicine 2006; 10.1136.
[11]. J D Rees, A M Wilson, et al.Review.Current concepts in the management of tendon disorders. Oxford Journals, Rheumatology 2006; 45(5): p.508-521.

[12]. Per Jonsson, Per Wahlstrom, et al. Eccentric training in chronic painful impingement syndrome of the shoulder: results of a pilot study. Knee Surgery, Sports Traumatology, Arthroscopy Journal 2005;vol.14.No.1, p.76-81.
[13]. Per Jonsson, H Alfredson, et al. Superior results with eccentric compared to concentric quadriceps training in patients with jumper's knee: a prospective randomised study. British Journal of Sports Medicine 2005; 39; 847-850.
[14]. L Ohberg, R Lorentzon, et al. Eccentric training in patients with chronic Achilles tendinosis: normalised tendon structure and decreased thickness at follow up. British Journal of Sports Medicine 2004; 38:8-11.
[15]. Shalabi A, Svensson L, et al. Eccentric training of the gastrocnemius-soleus complex in chronic Achilles tendinopathy result in decreased tendon volume and intratendinous signal as evaluated by MRI. American Journal of Sports Medicine 2004; 32(5): 1286-96.
[16]. H Alfredson, L Ohberg, et al. Is vasculo-neural ingrowth the cause of pain in chronic Achilles tendinosis? Knee Surgery, Sports Traumatology, Arthroscopy Journal 2004;vol 11:334-338.
[17]. L Ohberg, H Alfredson, Effects on neo-vascularisation behind the good results with eccentric exercise training in chronic mid-portion Achilles tendinosis? Knee Surgery, Sports Traumatology, Arthroscopy Journal 2004;vol 12:465-470.
[18]. Martin Fahlstrom, Ronny Lorentzon, et al. Chronic Achilles tendon pain treated with eccentric calf-muscle training. Knee Surgery, Sports Traumatology, Arthroscopy Journal 2003; 11:p.327-333.
[19]. Svernlov B, Adolfsson L, Non-operative Treatment Regime Including Eccentric Training for Lateral Humeral Epicondylalgia. Scandinavian Journal of Medicine and Science in Sports, 2001.
[20]. P C Lastayo, T E Reich, et al. Chronic eccentric exercise: improvement in muscle strength results with little demand for oxygen. Am J Physiol Regul Integr Comp Physiol 276,1999; R611-R615.
[21]. Jensen K,Di Fabio R P, et al. Evaluation of eccentric exercise in treatment of patellar tendinitis. Physical Therapy Journal 1989; 69(8): 700-2.
[22]. Y Kurtias, Ulus Y, et al. Adding Ultrasound in the Management of Soft Tissue Disorders of the Shoulder: A Randomised Placebo-Controlled Trial. Physical Therapy Journal April 2004;vol 84.No.4.
[23]. Valma J Robertson, Kerry G Baker. A Review of Therapeutic Ultrasound: Effectiveness Studies.Physical Therapy Journal 2001; vol.81, no.7, p.1339-1350.
[24]. C A Sped, Review.Therapeutic Ultrasound in soft tissue lesions. Rheumatology 2001; 40:1331-1336.
[25]. Van Der Heijden, Leffers P, et al. No effect of bipolar interferential electrotherapy and pulsed ultrasound for soft tissue shoulder disorders: a randomised controlled trial. Ann Rheum Dis 1999; 58(9) 530-40.
[26]. Klaiman, Mark D, et al. Phonophoresis versus Ultrasound in the treatment of common musculoskeletal conditions. Medicine and Science in sports and exercise 1998; 30(9):p.1349-1355.
[27]. Kim E, Hwa Jae Jeong, et al. Interpreting positive signs of the supraspinatus test in screening for torn rotator cuff. ACTA Med Okayama 2006; 60(4): 223-228.
[28]. Yoshitsngu Takeda, Kenji Endo, et al. The most effective exercise for strengthening the supraspinatus muscle: evaluation by magnetic resonance imaging. The American Journal of Sports Medicine 2002; 30:374 – 381.
[29]. Joy C MacDermid, Patty Solomon, et al. The Shoulder Pain and Disability Index demonstrate factor, construct and longitudinal validity. BMC Musculoskeletal Disorders 2006; 7:12.
[30]. Donald D Price, Patricia A McGrath, et al. The Validation of Visual Analogue Scales as Ratio Scale Measures for Chronic and Experimental Pain. Pain 1983;17.45-56 Elseiver.
[31]. Susan L Heald, Daniel L Riddle, et al. The Shoulder Pain and Disability Index: The Construct Validity and Responsiveness of a Region-Specific Disability Measure. Physical Therapy Journal, 1997; vol.77.no.10.
[32]. David J Magee, Orthopaedic Physical Assessment, 4th edition. Elsevier Science; 2006.p.263, 278,310.
[33]. Gotoh M, Hamada K, et al. Increased substance P in sub acromial bursa and shoulder pain in rotator cuff diseases. Journal of Orthopaedic Research 1998; 16(5) 618-21.
[34]. Chansky H A, Iannotti, The vascularity of the rotator cuff. Clinical Sports Medicine 1991; 10(4): 807-22.
[35]. Itoi E, Kido T, et al. Which is more useful, the"full can test" or "the empty can test" in detecting the tear of supraspinatus tendon? American Journal of Sports Medicine 1999; 27(1): 65-8.
[36]. Townsend H, Jobe F W, et al. Electromyographic analysis of the glenohumeral muscles during a baseball rehabilitation program. American Journal of Sports Medicine 1991; 19(3): 264-72.
[37]. Toni S Roddey, Sharon L Olson. Comparison of the University of California-Los Angeles Shoulder Scale and the Simple Shoulder Test With the Shoulder Pain and Disability Index: Single Administration Reliability and Validity. Physical Therapy Journal.2000; vol.80.no.8.
[38]. Wang, James H, et al. Biomechanical Basis for Tendinopathy. Clinical Orthopaedics and Related Research 2006; 443:320-332.
[39]. Lohr J F, Uhthoff H K, The microvascular pattern of the supraspinatus tendon. Clinical Orthopaedic and Related Research 1990; 254:35-8.