European Journal of Molecular & Clinical Medicine

ISSN 2515-8260 Volume 9, Issue 7, Summer 2022

ORIGINAL RESEARCH

Effect of eccentric wrist extensor exercises in patients with chronic lateral epicondylitis: An Observational study

[1]Dr. Anil Kumar Sharma, [2]Dr. Amit Kumar Gupta, [3]Dr. Ashwani Singh, [4]Dr. Nikhil Gupta, [5]Dr. Smit Saurabh, [6]Dr. Sahil Bhagat

[1,2]Associate Professor, [3,6]Assistant Professor, [4,5]Senior Resident, Department of Orthopaedics, NCR Institute of Medical Sciences, Meerut, U.P., India

Correspondence:
Dr. Ashwani Singh
Assistant Professor, Department of Orthopaedics, NCR Institute of Medical Sciences, Meerut, U.P., India
Email: ashwani.singh2470@gmail.com

Received: 12 September, 2022 Received: 22 September, 2022 Accepted: 27 October, 2022

ABSTRACT

Aim: To evaluate the effect of eccentric wrist extensor exercises in patients with chronic lateral epicondylitis.

Material and methods: The present prospective observational study was conducted in the department of orthopaedics among 100 patients, who come to our institution with complaints of pain and tenderness on palpation over the lateral epicondyle of humerus. Patients assigned to Group received supervised therapeutic exercise program which include eccentric strengthening of the wrist extensors. Patients were provided with education manual regarding ergonomics and activity modification technique to avoid aggravation of symptoms. Patients were followed up at subsequent visits i.e. at 2 weeks, 6 weeks and 3 months and TEFS (Tennis Elbow Functional Score) and VAS for pain scores were documented at the time of presentation and at subsequent visits.

Results: Previous episode of lateral epicondylitis was reported among 25% of the subjects. Duration of present episode was reported by 60%, 28% and 12% of the patients since 1-5, 6-10 and >10 weeks respectively. Mean VAS score of pain at baseline, 2 weeks, 6 weeks and 3 months was 6.35, 4.31, 3.14 and 2.16 respectively with statistically significant difference when compared using anova test as $p<0.05$. It was found that TEFS score at all the intervals was decreasing.

Conclusion: The present study has shown great promise for the rehabilitationspecialist to use eccentric exercise torestore function, decrease pain, andimprove performance. So, it can be concluded that eccentric exercise is effective in treatment of lateral epicondylitis.

INTRODUCTION

Tennis elbow is characterized by pain and tenderness over the lateral epicondyle (LE)of the humerus and pain on resisted dorsi-flexion of the wrist, middle finger, or both[1].Therefore, the condition is usually defined as asyndromeof pain in the area of the lateral epicondyle that may be degenerative or failed healing tendon responserather than inflammatory. This term was first coined by Raunge in 1873[2]. Theorigin of the extensor carpi radialis brevis (ECRB) is the most commonly affected structure. It isgenerally a work-related or sport-related pain disorder[3,4].The incidence of the condition is about 4 to 7 per 1000 per year in the general

public but it is a upto 9.1% in tennis player. Most patients are of age 4th to 5th decade and there is equal incidence in men and women[2].

Tennis elbow is characterized by increased presence of fibroblasts, vascular hyperplasia, disorganized collagen in the origin of extensor carpi radialisbrevis[ECRB], the most commonly affected structure. Patient usually presents with pain in lateral side of elbow and also with pain increasing on resisted wrist extension. Tenderness can be elicited over lateral epicondyle on direct palpation. Any activites associated with over use of atrophic and less frequently used tendons can lead to lateral epicondylitis[5-7].

Tendinous microtrauma in cases of LE divided into following four stages[8]:

1) Inflammatory, reversible without pathological alterations.
2) Angiofibroblastic degeneration.
3) Tendinosis associated with structural alteration (tendon tear).
4) Fibrosis and calcification.

The mechanicalproperties of tendons are commonly determined by thestructure of protein molecular and the composition of theextracellular matrix. Strain upon a tendon normallypromotes cross-linkage and collagen deposition. Insituations of repetitive stretching, multiple microtears of thetendon potentially cause an irreversible denaturing of matrixproteins and proliferation of fibrous tissue. Over time,these scar tissues are vulnerable to repetitive forces, withsubsequent further tears. High-frequency cyclical traumaand immature repair result in more severe tears, withconsequent alteration and failure of musculo-tendinousbiomechanics and worsening of symptoms[9-11].

The chief complaints in lateral epicondylitis are increased pain, decreased grip strength and functional activities leading to significant affection in activities of daily living. Although the pathology exists in elbow region, patients present with gradual onset of pain on extension movements of the wrist and fingers and supination of forearm. Clinical features are tenderness at the lateral epicondyle, normal elbow range of motion and pain on resisted movements (particularly resisted third finger extension). Although the actual cause of clinical condition remains unknown[12-17].

Recent review articles[18-20] have addressed the use of patient's history, differential diagnosis, and physical examination in the diagnosis of lateral epicondylitis. Current treatment option in treating lateral epicondylitis consist of physiotherapy – therapeutic ultrasound, phonophoresis, electrical stimulation, manipulation, soft tissue mobilization, neural tension, friction massage, augmented soft tissue mobilization (ASTM), extra corporeal shock wave therapy, laser therapy, stretching and strengthening exercise other medical intervention like NSAIDS, orthosis, corticosteroid injection, autologous blood injection, botulinum type A injection and topical nitrate. Surgery recommended when conservative strategies fail to relieve lateral epicondylitis symptoms after 6 to 12 months including open, percutaneous and arthroscopic techniques. Another alternative is eccentric exercises[12,13].

Eccentric exercise (i.e. exercise using the elongationphase of muscle activity by loweringweights) as treatment for chronic tendon pain was proposed by Stanish et al[21], while the concept was developed by Alfredson and coworkers[22]. Whether eccentric graded exercise is superior toconventional concentric graded exercise (i.e. usingthe contraction phase of muscle activity by liftingweights according to a graded protocol), or a combinationof both, as treatment in the chronic stageof tendon pain has been a matter of debate. Earlier study did not report any significant differences between eccentric and concentric exercise were found[23].Hence the purpose of the present study was to evaluate the effect of eccentric wrist extensor exercises in patients with chronic lateral epicondylitis.

MATERIAL AND METHOD

The present prospective observational study was conducted in the department of orthopaedics among 100 patients, who come to our institution between June 2021 to September 2022 with complaints of pain and tenderness on palpation over the lateral epicondyle of humerus. Patients were enrolled in the study after obtaining written informed consent.All of these patients with chronic lateral epicondylitis (100 patients) were considered for the observing the effect of eccentric wrist extensor exercises in chronic lateral epicondylitis. The diagnosis of chronic lateral epicondylitis was made on the basis of history, physical examination and clinical examination. Patients with both gender were recruited in this study.

INCLUSION CRITERIA

Subjects with following characteristics were included in the study

1. Pain at lateral epicondyle with gripping.
2. Pain with resisted wrist extension.
3. Pain with passive wrist flexion with the elbow extension.
4. Tenderness on palpation over the lateral epicondyle of humerus.

EXCLUSION CRITERIA

1. Neurological impairments.
2. Aversion to manual contact.
3. Neuromuscular diseases.
4. Previous trauma to the elbow region.
5. Previous surgery to the elbow region.
6. Peripheral nerve entrapment.
7. Cervical radiculopathy.
8. Corticosteroid injection within 4 weeks.
9. Previous therapy for elbow joint (minimizing expectation bias).

Hematological Investigations was done like Hb, TLC, DLC, ESR, CRP,RBS, RA factor, Uric Acid was done at the time of presentation and repeated if needed during the course of further study of the patient.

PROCEDURE

Active and passive range of motion was carried out at elbow joint, wrist joint i.e. elbow and wrist extension and flexion with patient sitting. Patients were put to eccentric wrist extensor exercises based on 3 principles enlisted below:-

A. Load (resistance)
B. Speed (velocity)
C. Frequency of contractions

EXERCISES PROTOCOL FOR THE STUDY GROUP

Patients assigned to Group received supervised therapeutic exercise program which include eccentric strengthening of the wrist extensors. Eccentric extension was performed in the seated position with full elbow extension, forearmpronation, and maximum wrist extension. From this position, the patient were slowly lower wrist into flexion for a count of 30, using the contralateral hand to return the wrist to maximum extension. Patients were instructed to continue the exercise even when they experience mild discomfort and to stop the exercise if the pain worsens and becomes disabling. For whom the eccentric exercise could be performed without minor discomfort or pain, the load was increased using free weights based on the patients 10RM(RepetitionMaximum). Three sets of ten repetitions was performed during each treatment, with a one-minute rest interval between each set. Patients were

providedwitheducationmanualregarding ergonomics and activity modification technique to avoid aggravation of symptoms.

ASSESSMENT OF RESULTS

A)TEFS (Tennis Elbow Functional Score): Patients functional status was assessed by Tennis Elbow Function Scale (TEFS)[22]

B) VAS: Pain intensity was measured using the visual analogue scale (VAS). Pain intensity will be recorded at base line (pretest) and at the end of 4 weeks[23].

Patients were followed up at subsequent visits i.e. at 2 weeks, 6 weeks and 3 months and TEFS (Tennis Elbow Functional Score) and VAS for pain scores were documented at the time of presentation and at subsequent visits. The VAS consists of a 10cm horizontal line with two ends labelled as 0cm representing the "least pain imaginable" and 10cm the "worst pain imaginable". Patients were given instructions to intersect this VAS scale with a vertical line depending on their current level of pain.

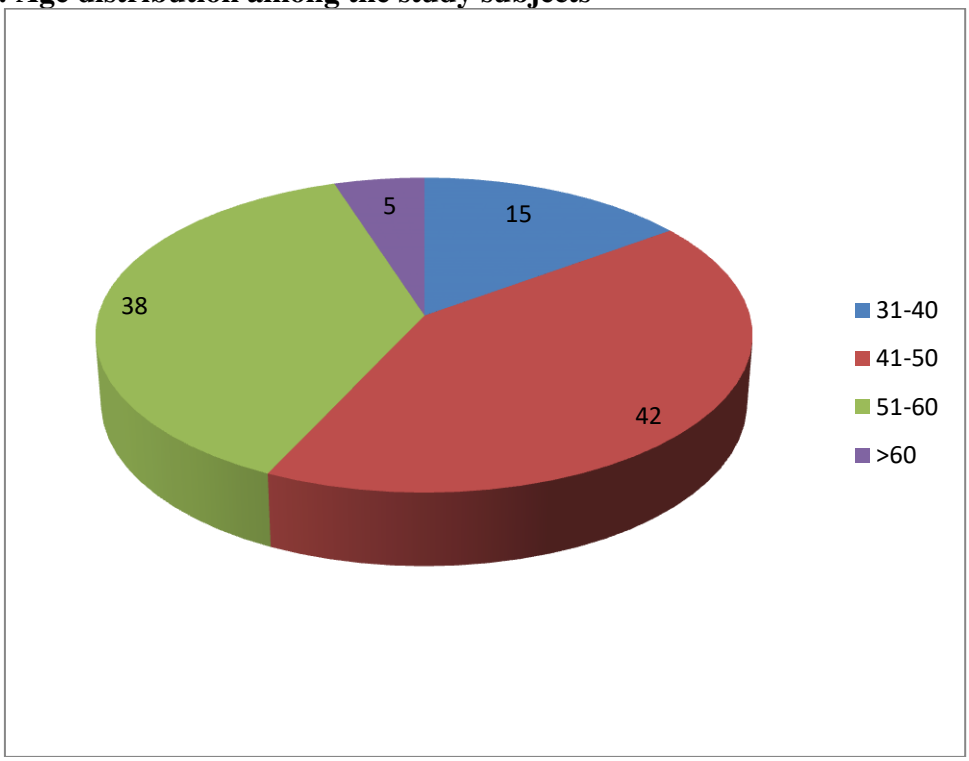
STATISTICAL ANALYSIS

Data so collected was tabulated in an excel sheet, under the guidance of statistician. The means and standard deviations of the measurements per group were used for statistical analysis (SPSS 22.00 for windows; SPSS inc, Chicago, USA). Comparison of TEFS and VAS was compared using ANOVA along with Tukey HSD Post-hoc Test and the level of significance was set at $p < 0.05$.

RESULTS

Out of 100 patients, 68% were males and 32% were females, showing male dominancy in our study. 15%, 42%, 38% and 5% of the subjects were having age of 31-40, 41-50, 51-60 and >60 years respectively. More than 2/3rd of the subjects were having age between 41-60 years (graph 1).

Graph 1: Age distribution among the study subjects



Graph 2 shows the smoking status among the study subjects. Smoking status was reported in 7% of the subjects.

Graph 2: Smoking status among the study subjects

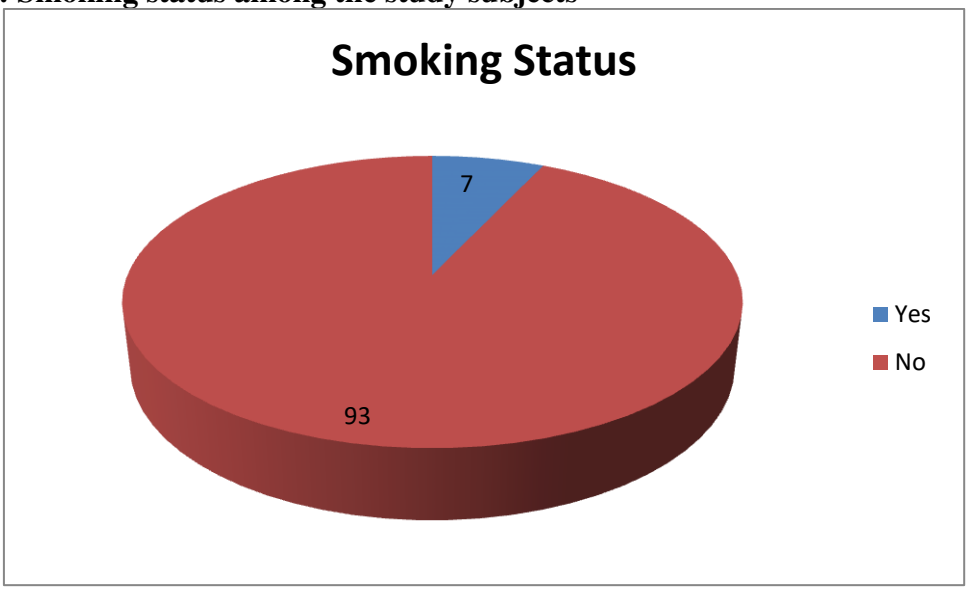


Table 1 shows the history of chronic lateral epicondylitis. 75% of the subjects did not reveal any previous episode of lateral epicondylitis. Previous episode of lateral epicondylitis was reported among 25% of the subjects. Duration of present episode was reported by 60%, 28% and 12% of the patients since 1-5, 6-10 and >10 weeks respectively. 34% of the subjects did not undergo any previous treatment while 9%, 50% and 7% of the subjects had received acupuncture, NSAID and steroid injections treatment respectively.

Table 1: History of chronic lateral epicondylitis

Variables	Number	Percentage
Number of previous episodes		
0	75	75
1	15	15
2	10	10
Duration of present episode (weeks)		
1-5	60	60
6-10	28	28
>10	12	12
Previous Treatments		
None	34	34
Acupuncture	9	9
NSAID	50	50
Steroid Injections	7	7

Mean VAS score of pain at baseline, 2 weeks, 6 weeks and 3 months was 6.35, 4.31, 3.14 and 2.16 respectively with statistically significant difference when compared using anova test as $p<0.05$. Tukey HSD Post-hoc Test was used to compare the VAS score at all the intervals with each other. It can be clearly appreciated that VAS score at all the intervals was decreasing. When VAS score was compared between baseline and 2 weeks, 6 weeks, 3 months; between 2 weeks and 6 weeks, 3 months; between 6 weeks and 3 months, it was found to be statistically significant as $p<0.05$ (table 2).

Table 2: Comparison of VAS score of pain at different intervals

Interval	Minimum	Maximum	Mean	SD	Anova Test	p value
Baseline	6	8	6.35	.657	74.19	<0.01*
2 Weeks	2	6	4.31	.692		
6 Weeks	2	5	3.14	.752		
3 Months	1	4	2.16	.526		
Tukey HSD Post-hoc Test...						
Baseline vs 2 Weeks: Diff=-2.0400, 95%CI=-2.2816 to -1.7984, p=0.0000*						
Baseline vs 6 Weeks: Diff=-3.2100, 95%CI=-3.4516 to -2.9684, p=0.0000*						
Baseline vs 3 Months: Diff=-4.1900, 95%CI=-4.4316 to -3.9484, p=0.0000*						
2 Weeks vs 6 Weeks: Diff=-1.1700, 95%CI=-1.4116 to -0.9284, p=0.0000*						
2 Weeks vs 3 Months: Diff=-2.1500, 95%CI=-2.3916 to -1.9084, p=0.0000*						
6 Weeks vs 3 Months: Diff=-0.9800, 95%CI=-1.2216 to -0.7384, p=0.0000*						

*: statistically significant

Mean TEFS score at baseline, 2 weeks, 6 weeks and 3 months was 36.35, 25.24, 18.30 and 14.16 respectively with statistically significant difference when compared using anova test as $p<0.05$. Tukey HSD Post-hoc Test was used to compare the TEFS score at all the intervals with each other. It can be clearly appreciated that TEFS score at all the intervals was decreasing. When TEFS score was compared between baseline and 2 weeks, 6 weeks, 3 months; between 2 weeks and 6 weeks, 3 months; between 6 weeks and 3 months, it was found to be statistically significant as $p<0.05$ (table 3).

Table 3: Comparison of TEFS at different intervals

Interval	Minimum	Maximum	Mean	SD	Anova Test	p value
Baseline	36	38	36.35	.657	49.51	<0.01*
2 Weeks	21	28	25.24	1.923		
6 Weeks	16	22	18.30	1.789		
3 Months	13	16	14.16	.526		
Tukey HSD Post-hoc Test...						
Baseline vs 2 Weeks: Diff=-11.1100, 95%CI=-11.6130 to -10.6070, p=0.0000*						
Baseline vs 6 Weeks: Diff=-18.0500, 95%CI=-18.5530 to -17.5470, p=0.0000*						
Baseline vs 3 Months: Diff=-22.1900, 95%CI=-22.6930 to -21.6870, p=0.0000*						
2 Weeks vs 6 Weeks: Diff=-6.9400, 95%CI=-7.4430 to -6.4370, p=0.0000*						
2 Weeks vs 3 Months: Diff=-11.0800, 95%CI=-11.5830 to -10.5770, p=0.0000*						
6 Weeks vs 3 Months: Diff=-4.1400, 95%CI=-4.6430 to -3.6370, p=0.0000*						

*: statistically significant

DISCUSSION

The eccentric exercise program introduced in our studyproved to be an effective method of treating chroniclateral epicondylosis. All outcome measures for chroniclateral epicondylosis were markedly improved. There are many different approaches to the treatment ofchronic lateral epicondylosis, such as phonophoresis or iontophoresis, corticosteroid injections, extracorporeal shockwave therapy, topical nitric oxide and bracing. These are commonly provided independently or as part ofstandard physical therapy. Compared to eccentricstrength training, treatments such as iontophoresis, phonophoresis[24],extracorporeal shockwave therapy[25], corticosteroidinjections, or topical nitric oxide are expensive[26], require direct medical supervision, and, in some cases, havesignificant side effects[27,28]. While the efficacy of eccentric training for the treatment of tendinopathies invarious joints has been clearly established, theadditional benefit of this treatment is that it can be performed as part of a home program and does not involvecontinued medical supervision. Not only does this

providea cost benefit, but treatment dosage is not limited by thepatient having to come to a clinic or needing directsupervision.

In this study, 75% of the subjects did not reveal any previous episode of lateral epicondylitis. Previous episode of lateral epicondylitis was reported among 25% of the subjects. Duration of present episode was reported by 60%, 28% and 12% of the patients since 1-5, 6-10 and >10 weeks respectively. 34% of the subjects did not undergo any previous treatment while 9%, 50% and 7% of the subjects had received acupuncture, NSAID and steroid injectionstreatment respectively.Magnus Peterson et al in their study revealed similar results i.e. NSAID, acupuncture and steroid injections as treatment was received by 50%, 30% and 35% of the subjects respectively[29].

Mean VAS score at baseline, 2 weeks, 6 weeks and 3 months was 6.35, 4.31, 3.14 and 2.16 respectively with statistically significant difference when compared using anova test as $p<0.05$. Tukey HSD Post-hoc Test was used to compare the VAS score at all the intervals with each other. It can be clearly appreciated that VAS score at all the intervals was decreasing. When VAS score was compared between baseline and 2 weeks, 6 weeks, 3 months; between 2 weeks and 6 weeks, 3 months; between 6 weeks and 3 months, it was found to be statistically significant as $p<0.05$. Given the foregoing, the eccentric control exercise stimulated the mechanoreceptors in the tenocytes,thus leading to the generation of collagen and recovery from Chronic Lateral Epicondylitis accompanied by pain relief.

The theory behind eccentric strengthening is to load the musculotendinous unit inducing hypertrophy and increasing tensile strength. This in turn reduces the strain on the tendon during activities. Eccentric contraction can create a greater stimulus for the cells of the tendon, producing collagen and resulting in the tendon being able to withstand greater forces. Decreasing neovascularization has been recently documented as another benefit of eccentric strengthening. It is believed that neovascularization is a causing factor of pain in LE and other tendionpathies[30]. Eccentric execution results in greater force production with less energy expenditure and less oxygen consumption compared to concentric execution. Nosaka et al[31] demonstrated the “repeated bout effect”. After full recovery has been achieved following the first eccentric overload bout, a repeated training results in minimal symptoms of muscle damage allowing eccentric overload to become a viable training means, especially when considered that the “repeated bout effect” can last for several months. The exact mechanisms are not well defined but it seems to involve neural, mechanical and cellular adaptations [Nosaka, 2001][31]. Therapeutic exercise programs appear to reduce pain and improve function in persons with lateral epicondylitis. Current literature has found connections between eccentric loading and positive outcomes in tendonopathy patients.

A previous small-scale study ofshort duration found no significant differencesbetween eccentric and concentric exercise in chronic tennis elbow[32]. In a study by Magnus Peterson et al, eccentricexercise reduced pain faster than concentricexercise in chronic tennis elbow[29]. This supports previousstudies on Achilles tendinosis showingeccentric exercise to be superior to concentricexercise. These results are in accordance to our study[33,34].Vicenzino et al.[35] indicated that in the interventions for lateral epicondylitis patients,the experimental group that performed the Mulligan lateral mobilization of the proximal forearm showed more significantincreases in the threshold of the lateral epicondyle as treatment effects than the placebo group and the control group.

However Woodley et al. found limited evidence thateccentric exercise has a positive effect on pain, function, and patient satisfaction/return-to-workwhen compared with other treatment interventions[36].

Mean TEFS score at baseline, 2 weeks, 6 weeks and 3 months was 36.35, 25.24, 18.30 and 14.16 respectively with statistically significant difference when compared using anova test as $p<0.05$. It can be clearly appreciated that TEFS score at all the intervals was decreasing. The

results of our study are in accordance with the findings of a randomized controlled trial conducted by Roos EM et al in 2004[37]. He and his colleagues found that eccentric exercise is more effective in treating tendinosis than splinting. A similar study was conducted among persons with chronic patellar tendinopathy in which eccentric exercises were compared with some physical agents[38].

The strengths of the study include that the studypopulation was recruited from among chronic lateral epicondylitis patients in primary healthcare. Althoughthis was not a random population sample, it may beregarded as fairly representative of this type ofpatient in the general population. The sameobserver did all measurements, thereby avoidinginterobserver variation. The monitoring was intense, resulting in a high participation rate. Thedata loss in the trial was low. Moreover, the intention-to-treat analysis strategy was used, therebyminimising the bias risk. Pain scoring using visualanalogue scales (VAS) has previously been validated. The scoring has considerable inter-patientvariability, but intra-patient variability over time, as used in this study, is low.

A small sample size is a limitation of this study. Investigators in future trials should recruit larger numbers of subjects. No long term follow- up data was collected past 3 months; therefore the long-term effects of the interventions in the present study remain unknown. Future research is warranted that would determine the long term effects of the interventions used in this study. We also recommend physical therapists to follow the eccentric exercise protocol for optimal reduction of symptoms among persons with lateral epicondylitis.

CONCLUSION

The present study has shown great promise for the rehabilitationspecialist to use eccentric exercise torestore function, decrease pain, andimprove performance. So, it can be concluded that eccentric exercise is effective in treatment of lateral epicondylitis.Eccentricexercise should be an integralcomponent of any lateral epicondylitis rehabilitation program, notonly because evidence suggests eccentricwork to be superior to conventionalinterventions but also becauseit is based off sound physiologicalprinciples. This study found no adverse effects arising from the prescription of eccentric exercise as a treatment for lateral epicondylitis. The absence of adverse effects, coupled with evidence of improved pain and function recovery, lends support to the inclusion of eccentric exercise within a multimodal treatment programme for the rehabilitation of patients with lateral epicondylitis.

The standardisation of lateral epicondylitis diagnostic testing and clearly defined eccentric exercise parameters should be a priority for future research. Studies should also consider the long-term effectiveness of these exercise programmes.

REFERENCES

1. Assendelft W, Green S, Buchbinder R, Struijs P, Smidt N. Tennis elbow. BMJ 2003;327:329.
2. Runge F. Zurgenese und behandlung des schreibekrampfes. BerlKlinWochenschr 1873; 10: 245–248
3. Stasinopoulos D, Johnson IM. Lateral elbow tendinopathy is the most appropriate diagnostic term for the condition commonly referred to as lateral epicondylitis. Medical Hypotheses 2006;67:1399–1401.
4. Assendelft W, Green S, Buchbinder R. Tennis elbow. BMJ 2003;327:329.
5. Viikari-Juntura E, Kurppa K, Kuosma E, et al. Prevalence of epicondylitis and elbow pain in the meat-processing industry. Scand J Work Environ Health 1991;17:38-45.
6. Garg A, Hegmann KT, Wertsch JJ, Kapellusch J, Thiese MS, Bloswick D, et al. The WISTAH hand study: A prospective cohort study of distal upper extremity musculoskeletal disorders. BMC MusculoskeletDisord 2012;13:90.

7. Waseem M, Nuhmani S, Ram CS, Sachin Y. Lateral epicondylitis: A review of the literature. J Back MusculoskeletRehabil 2012;25:131‑42.
8. Parmar BA, Shukla YU. Effect of eccentric versus concentric exercise on pain, grip strength and function in lateral epicondylitis - a comparative study. International Journal of Science & Healthcare Research. 2020; 5(2): 98-109.
9. Eygendaal D, Rahussen FTG, Diercks RL. Biomechanics of the elbow joint in tennis players and relation to pathology. British Journal of Sports Medicine 2007;41:820–823.
10. Taylor SA, Hannafin JA. Evaluation and management of elbow tendinopathy. Sports Health 2012;4:384–393.
11. Walz DM, Newman JS, Konin GP. Epicondylitis: pathogenesis, imaging, and treatment. Radiographics, 2010;30:167–184.
12. Orchard J, Kountouris A. The management of tennis elbow – clinical review. BMI 2011:342:d2687.
13. Dingemanse R, Randsdorp M, Koes BW, Huisstede BM. Evidence for the effectiveness of electrophysical modalities for treatment of medial and lateral epicondylitis: a systematic review. British journal of sports medicine. 2014;48(12):957-65.
14. Brukner P and Khan K. Clinical sports medicine, 3rd edition. Tata Mc Graw-Hill, publishing company limited, 2008.
15. Rees JD, Wilson AM and Wolman RL. Current concepts in the management of tendon disorders. Rheumatol (Oxford, England) 2006; 45: 508–521.
16. Peterson M, Elmfeldt D, Svardsudd K. Treatment practice in chronic epicondylitis: a survey among general practitioners and physiotherapists in Uppsala County, Sweden. Scandinavian journal of primary health care 2005; 23:239–241.
17. Haahr JP and Andersen JH. Prognostic factors in lateral epicondylitis: a randomized trial with one-year followup in 266 new cases treated with minimal occupational intervention or the usual approach in general practice. Rheumatol (Oxford, England) 2003; 42: 1216–1225.
18. Ma KL, Wang HQ. Management of Lateral Epicondylitis: A Narrative Literature Review. Pain Research and Management. 2020 May 5;2020.
19. Johnson GW, Cadwallader k, Scheffel SB, Epperly T. Treatment of lateral epicondylitis. Am FAM physician, 2007; 76(6):843-48.
20. Cohen M, Motta GDR. Lateral epicondylitis of elbow. Rev Bras Ortop.2012; 47(4)414-20.
21. Stanish WD, Rubinovich RM and Curwin S. Eccentric exercise in chronic tendinitis. Clinic Orthop Related Res 1986; (208): 65–68.
22. Lowe KA. Test/retest reliability, construct validity, and responsiveness of the tennis elbow function scale. Edmonton, Alberta, Fall 1999.
23. Collins SL, Moore RA, McQuay HJ. The visual analogue pain intensity scale: what is moderate pain in millimetres?. Pain. 1997;72(1-2):95-7.
24. Baskurt F, Ozcan A, Algun C. Comparison of effects of phonophoresis and Iontophoresis of naproxen in the treatment of lateral epicondylosis. ClinRehabil 2003;17:96-100.
25. Chung B, Wiley JP. Effectiveness of extracorporeal shock wave therapy in the treatment of previously untreated lateral epicondylosis: a randomized controlled trial. Am J Sports Med 2004;32:1660-7.
26. Bisset L, Beller E, Jull G, Brooks P, Darnell R, Vicenzino B. Mobilisation with movement and exercise, corticosteroid injection, or wait and see for tennis elbow: Randomised trial. BMJ 11-4-2006;333:939.
27. Altan L, Kanat E. Conservative treatment of lateral epicondylosis: comparison of two different orthotic devices. ClinRheumatol 2008;27:1015-9.

28. Paoloni JA, Appleyard RC, Nelson J, Murrell GA. Topical nitric oxide application in the treatment of chronic extensor tendinosis at the elbow: a randomized, double-blinded, placebo-controlled clinical trial. Am J Sports Med 2003;31:915-20.
29. Peterson M, Butler S, Eriksson M, Svärdsudd K. A randomized controlled trial of eccentric vs. concentric graded exercise in chronic tennis elbow (lateral elbow tendinopathy). Clinical rehabilitation. 2014;28(9):862-72.
30. Calfee RP, Patel A, DaSilva MF, Akelman E. Management of lateral epicondylitis: Current concepts. Journal of American Academy of Orthopaedic Surgery 2008;16(1):19-29.
31. Nosaka K, Sakamoto K, Newton M, & Sacco P. The repeated bout effect of reduced-load eccentric exercise on elbow flexor muscle damage. European Journal of Applied Physiology 2001;85: 34-40.
32. Martinez-Silvestrini JA, Newcomer KL, Gay RE, Schaefer MP, Kortebein P, Arendt KW. Chronic lateral epicondylitis: comparative effectiveness of a home exercise program including stretching alone versus stretching supplemented with eccentric or concentric strengthening. J Hand Ther 2005; 18: 411–419.
33. Mafi N, Lorentzon R, Alfredson H. Superior shortterm results with eccentric calf muscle training compared to concentric training in a randomized prospective multicenter study on patients with chronic Achilles tendinosis. Knee Surg Sports TraumatolArthrosc 2001; 9: 42–47.
34. Niesen-Vertommen SL, Taunton, JE, Clement DB, Mosher RE. The effect of eccentric versus concentric exercise in the management of Achilles tendinitis. Clin J Sport Med 1992; 2: 109–113.
35. Vicenzino B, Paungmali A, Buratowski S, et al: Specific manipulative therapy treatment for chronic lateral epicondylalgia produces uniquely characteristic hypoalgesia. Man Ther, 2001, 6: 205–212.
36. Woodley B, Newsham-West R and Baxter G. Chronic tendinopathy: effectiveness of eccentric exercise. Br J Sports Med 2007; 41: 188–198.
37. Roos EM, Engstrom M, Lagerquist A, Soderberg B. Clinical improvement after 6 weeks of eccentric exercise in patients with mid-portion Achilles tendinopathy: a randomized trial with 1-year follow-up. Scandinavian Journal of Medicine & Science in Sports 2004;14:286–295.
38. Stasinopoulos D, Stasinopoulos I. Comparison of effects of exercise programme, pulsed ultrasound and transverse friction in the treatment of chronic patellar tendinopathy. Clinical Rehabilitation 2004;18:347–352.