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Comparison of efficacy of the eccentric concentric training of wrist extensors with static stretching versus eccentric concentric training with supinator strengthening in patients with tennis elbow: A randomized clinical trial.

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ABSTRACT

Introduction. Lateral epicondylitis or tennis elbow is a disease of common extensor muscles origin of elbow presenting with pain over the lateral epicondyle or pain of wrist extensor muscles. Tennis elbow is a very common overuse injury. It may be seen in sports population and also in normal individuals. Occurs commonly between the age group of 35-55years. **Objectives.** This study is intended to find and compare the effectiveness of eccentric - concentric training of wrist extensors with static stretching and an eccentric - concentric training combined with supinator strengthening in the lateral epicondylitis in reducing pain and increasing grip strength in lateral epicondylitis. **Design.** A randomized control study. **Materials and Methods.** 68 subjects both male and females with lateral epicondylitis belonging to Age group ranging from 35 to 55years who fulfilled the inclusion and exclusion criteria were selected for the study and were randomly assigned into the two groups i.e. group A and B. Group A was treated with eccentric - concentric training of wrist extensors with static stretching and Group B was treated with eccentric - concentric training combined with supinator strengthening. Outcome was measured in terms of VAS scale for pain, Hand Held Dynamometer for grip strength evaluation and Patient-Rated Tennis Elbow Evaluation Questionnaire (PRTEE) scale for functional disability on baseline, 1st month, 2nd month, 3rd month and 6th month. **Results.** In the present study intra group comparison result showed that pain relief, improved grip strength, and reduced functional disability was statistically significant in both the group. Whereas inter group comparison results revealed that group B eccentric - concentric training combined with supinator strengthening showed highly significant difference (P<0.0001) as compared to group A eccentric - concentric training of wrist extensors with static stretching. **Conclusion.** Study findings concluded that group B eccentric - concentric training combined with supinator strengthening gave better response and is more effective than eccentric - concentric training of wrist extensors with static stretching in reducing pain and increasing grip strength in lateral epicondylitis.

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KEYWORDS: *Lateral elbow tendinopathy (LET), Grip strength, Supinator strengthening, Extensor carpi radialis brevis, Tennis elbow, Eccentric concentric training (ECT)*

INTRODUCTION

Lateral epicondylalgia, lateral epicondylosis, tennis elbow and or lateral epicondylitis are inappropriate clinical diagnostic terms due to pathophysiological, anatomical aetiological and factors.[1] Therefore, lateral elbow tendinopathy (LET) is the most appropriate clinical diagnostic term. LET is related to sport or arm work pain disorder.[2] The condition is usually defined as a syndrome of pain in the area of the lateral epicondyle [3-4] that may be degenerative or failed healing tendon response rather than inflammatory. Hence, the increased presence of fibroblasts, vascular hyperplasia, proteoglycans and glycosaminoglycans together with disorganised and immature collagen may all take place in the absence of inflammatory cells.[5] Lateral epicondylitis is a common clinical entity seen in general practice as well as orthopaedics and sports medicine. Despite its high prevalence, the etiology and Pathophysiology remains poorly understood, and treatment methods have not been adequately studied. The etiology of lateral epicondylitis is unclear. Histologic studies have not documented evidence of inflammation in chronic lateral epicondylosis[5, 6] or in other chronic tendinopathy, including Achilles, [7, 8] patellar,[4,7] and rotator cuff.[10] These conditions all appear to represent tendinosis, with disordered collagen bundles, abnormal cellularity, increased mucoid ground substance, and random neovascularization, commonly termed *mucoid degeneration*.[7] In lateral epicondylitis, this degeneration occurs in the tendon of the Extensor carpi radialis brevis.

Various intrinsic factors are the cause for the chronic lateral epicondylitis which are discussed in numerous literatures.[11, 12] Literatures suggest that extensor muscle groups are affected primarily in the lateral epicondylitis. The studies discussed that extensor carpi radialis brevis is affected due to repeated wrist motions. Tear of the tendon at the junction between the muscle and bone leads to poor healing of the tissues this is due to lack of overlying periosteal tissues. Repetitive movement creates micro trauma which may occur due to overuse or abnormal joint biomechanics, leading to overload of the repairing tissues, this mechanically distort scar tissue and thus stimulate free nerve endings to evoke mechanical nociceptive pain.[13] There will be a fibroblastic proliferation of the tendon which will esult in degenerative process or failed reparative process result more than acute inflammation. The main complaints of patients with LET are pain and decreased function[15] both of which may affect daily activities. Diagnosis is simple, and a therapist should be able to reproduce this pain in at least one of three ways:(1) palpation on the facet of the lateral epicondyle; (2) with the elbow in extension, resisted wrist extension and or resisted middle-finger extension; and (3) gripping activities.[2, 16, 17] The Patient-Rated Tennis Elbow Evaluation questionnaire provides a quick, standardized, and easy quantitative description of functional disability and pain in LET patients.[18] A plethora of physiotherapy techniques, electrotherapeutic and non-electrotherapeutic modalities, has been recommended for the management of LET.[2, 3, 16, 19, 20] These treatments have different theoretical mechanisms of action, but all have the same aim, to reduce pain and improve function.[2] Many treatment options have been proposed for the rehabilitation of patients with lateral epicondylitis, the effectiveness of which are largely unknown. These include exercise, massage, manipulation, taping, acupuncture, orthotic devices, ultrasound, activity modification, and rest.[2,21,22,23] Identifying an effective treatment programme for patients with lateral epicondylitis would have significant benefits for patient recovery and for the delivery of an improved service by healthcare providers.[24] Exercise programmes incorporating eccentric muscle activity are becoming increasingly popular as they are considered to provide a more effective treatment than other forms of exercise therapy.[25,26] At present, the role of eccentric exercise in the treatment of lateral epicondylitis is not entirely clear. A systematic review by Malliaras et al.[27] showed promising results in support of eccentric exercise as a treatment for lateral epicondylitis, Malliaras and his colleagues concluded that clinicians should consider eccentric-concentric loading alongside or instead of eccentric loading in tendinopathy. [27]A pilot trial showed that an exercise program, consisting of isotonic strengthening, including eccentric, had reduced the pain in patients with rotator cuff tendinopathy at the end of the treatment and three months after the end of treatment.[28]

Not only the wrist extensors and especially ECRB but also the supinator may be involved in LET.[1] the exercise program should include exercises not only for wrist extensors strengthening but also for supinator strengthening. Based mainly on clinical experience, supinator weakness is commonly addressed in LET patients as increasing pain, decreasing functional ability and hand - grip strength. To our knowledge, there have been no studies to compare the effectiveness of Eccentric concentric training with static stretching and supinator strengthening in the management of lateral epicondylitis. It is possible to compare eccentric- concentric training of wrist extensors with supinator strengthening to see if the combination of the above reported therapeutic approaches over's superior results to eccentric – concentric training with static stretching in LET patients. Therefore, the aim of the present article was to make a comparison of the effects of an exercise programme consisting of eccentric - concentric training of wrist extensors with strengthening of supinator muscle exercises and an exercise programme consisting of eccentric - concentric training of wrist extensors with static stretching for the treatment of LET.

METHOD

A randomized clinical trial was conducted in an outpatient department, at N.R. institute of Physiotherapy, Ahmedabad. Patients were referred by orthopaedic consultant and different physiotherapy centers and also self-referral to the centre. Total 68 patients with tennis elbow were assigned to either group A (n= 34, 16 men, 18 women; age- 44.58 ± 5.53 years) receiving ECT with static stretching and group B (n= 34, 19 men, 15 women; age - 43.97±5.93years) that receiving ECT training with supinator strengthening.

STUDY POPILATION AND METHODS

Study design

The study was carried out to comparing the effects of eccentric-concentric training of wrist extensors with static stretching versus eccentric-concentric training of wrist extensors with supinator strengthening exercise. The present study was performed as a randomized controlled trial during 6 months of period to find out the effect of eccentric-concentric training of wrist extensors with static stretching of ECRB and eccentric-concentric training of wrist extensors with supinator strengthening on reducing pain and increasing muscle strength in lateral epicondylitis patients.

Study population

For the main study total 90 tennis elbow patients are referred form general practitioners, orthopaedic doctors, different physiotherapy centers and some patients referred by their self. Recruitment for the main study was performed by chief author (M.P) and 20 patients referred from general practitioners, 40 from orthopaedic doctors from different hospitals, and 30 recruited through different physiotherapy centers were finally included.

Patients were included in the study if, they were between 35 to 55 years of age, they had been evaluated as having clinically diagnosed LET for at least 3 month or more duration. Patients were included in the trial if they reported (a) pain on the facet of the lateral epicondyle when palpated, (b) unilateral symptomatic lateral epicondylitis, (c) Tenderness on palpation over the lateral epicondyle of humerus, (d) patients with positive -Thomsen test and Mill's test.

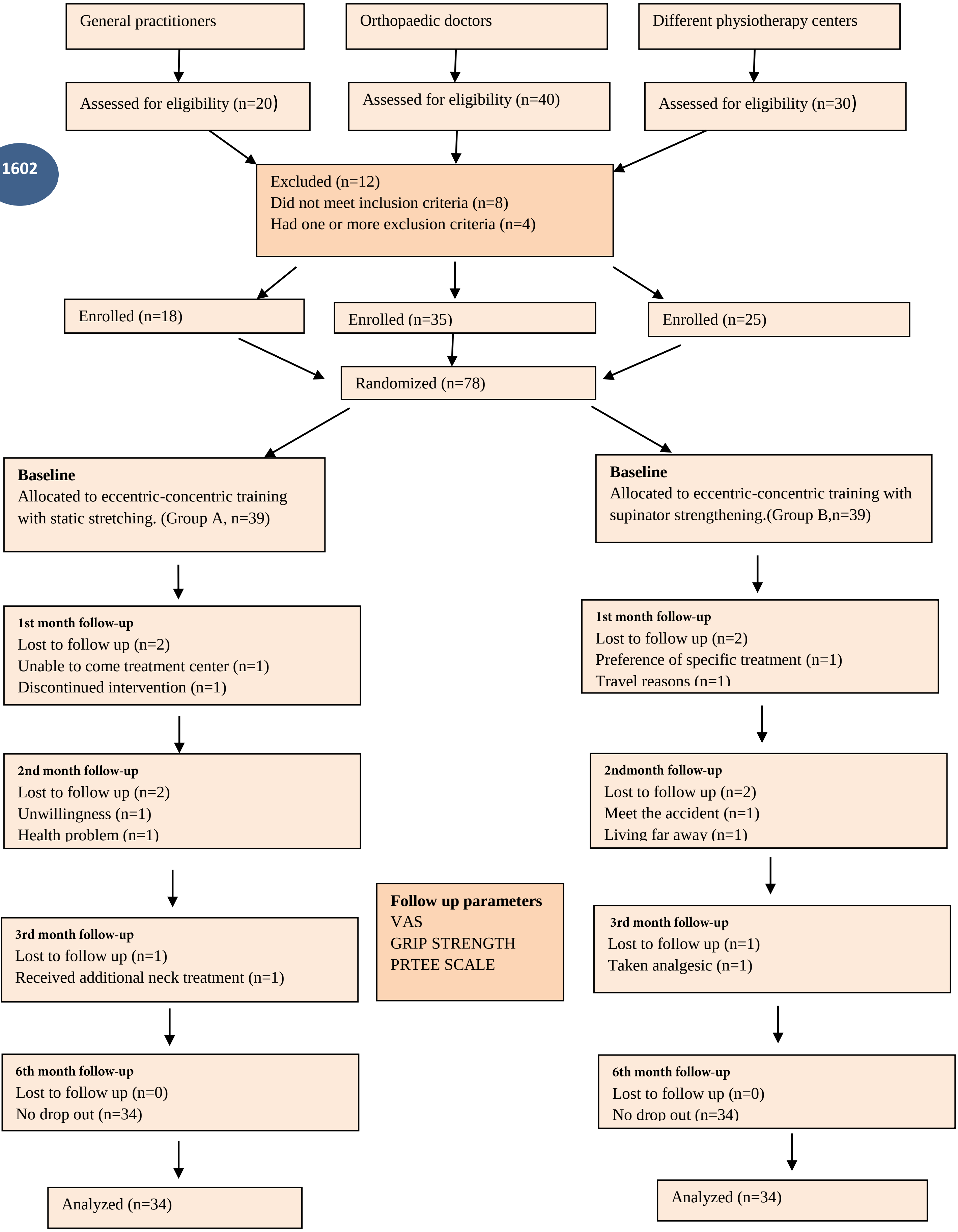
Patients were excluded from the study if they had one or more of the following conditions: (a) dysfunction in the shoulder, neck and thoracic region (b) Cervical radiculopathy (c) radial nerve entrapment (d) Corticosteroid injection within 6 months (e) had received any conservative treatment for the management of LET in the 4 weeks before entering the study (f) Previous surgery to the elbow region.

All patients received a written explanation of the trial prior to entry into the study. All patients gave signed informed consent to participate in the study.

RANDOMIZATION PROCEDURE

Three authors were involved in the study: (1) the primary author (MP) who evaluated the patients to confirm the LET diagnosis and decide inclusion and exclusion criteria for study. (2) The patients in the present study were randomised by computer software by author (SB). A simple randomization sequence was computer-generated by one of the authors (SB) of the study who was not directly involved with the assessments and treatment of patients. The allocation was concealed by using consecutively numbered, sealed, opaque envelopes. Eligible patients were allocated to the treatment groups (ECT training with static stretching or ECT training with supinator strengthening) by a (MP) Chief physical therapist that opened the next available numbered envelope prior to the first treatment session. And All participants in both groups performed the exercises under the supervision of the two physical therapist assistant (PTA). (3) outcome measure analysis and follow up taken by third author (JB) at baseline, at 1st month,2nd month,3rd month and at end of 6th month stastical analysis done by primary author (MP).All treatments were conducted by PTA who was blind to the patients therapy group. Third author (JB) interviewed each patient to ascertain baseline, including patient name, sex, age, duration of symptoms, previous treatment, occupation, affected arm. The subjects in the present study were randomised by computer software by author (SB) and blindly assigned by author (MP) to either an eccentric-concentric training of wrist extensors with static stretching group A (n = 34) or eccentric-concentric training of wrist extensors with supinator strengthening group B (n = 34) by means of a random block design. The SAS 'ranuni' function, generating random numbers with equal probability distribution, was programmed so that for each consecutive four participants, two were randomly allocated to the ECRB stretching group and two to the supinator strengthening group DATA Collection Data were collected at base-line and at follow-up visits at 1, 2, 3 and 6 months after the base-line visit. At baseline, information was collected regarding age, sex, involved side, and duration of symptoms, tennis elbow history, and previous treatment given during the current episode.

Flow chart


General practitioners
Orthopaedic doctors
Different physiotherapy centers
Assessed for eligibility (n=20)
Assessed for eligibility (n=40)
Assessed for eligibility (n=30)
Excluded (n=12)
Did not meet inclusion criteria (n=8)
Had one or more exclusion criteria (n=4)
Enrolled (n=18)
Enrolled (n=35)
Enrolled (n=25)
Randomized (n=78)
Baseline
Allocated to eccentric-concentric training with static stretching. (Group A, n=39)
Baseline
Allocated to eccentric-concentric training with supinator strengthening.(Group B,n=39)
1st month follow-up
Lost to follow up (n=2)
Unable to come treatment center (n=1)
Discontinued intervention (n=1)
1st month follow-up
Lost to follow up (n=2)
Preference of specific treatment (n=1)
Travel reasons (n=1)
2nd month follow-up
Lost to follow up (n=2)
Unwillingness (n=1)
Health problem (n=1)
2ndmonth follow-up
Lost to follow up (n=2)
Meet the accident (n=1)
Living far away (n=1)
Follow up parameters
VAS
GRIP STRENGTH
PRTEE SCALE
3rd month follow-up
Lost to follow up (n=1)
Received additional neck treatment (n=1)
3rd month follow-up
Lost to follow up (n=1)
Taken analgesic (n=1)
6th month follow-up
Lost to follow up (n=0)
No drop out (n=34)
6th month follow-up
Lost to follow up (n=0)
No drop out (n=34)
Analyzed (n=34)
Analyzed (n=34)

All patients were instructed to use their arm during the course of the study but to avoid activities that irritated the elbow such as grasping, lifting, knitting, handwriting, driving a car and using a screwdriver. They were also told to refrain from taking anti-inflammatory drugs throughout the course of the study. Patient compliance with this request was monitored using a treatment diary. Communication and interaction (verbal and non-verbal) between the therapist and patient was kept to a minimum, and behaviours sometimes used by therapists to facilitate positive treatment outcomes were purposefully avoided. For example, patients were given no indication of the potentially beneficial effects of the treatments or any feedback on their performance in the pre-application and post-application measurements.

INTERVENTION

Patients assigned to Group A received eccentric –concentric exercise training with static stretching which included static stretching of the Extensor Carpi Radialis Brevis followed by eccentric-concentric strengthening of the wrist extensors.

The exercise programme was the same for both groups. Both groups received an eccentric-concentric regime to be performed for three months with progressively increasing load on the affected forearm extensor muscles. The loading equipment consisted of plastic water

Container with a handle. The initial load was standardised to 1 kilogram (one litre of water) for women and 2 kilograms for men. The participants sat in a chair and supported the forearm on the armrest or on an adjacent table. Both groups were instructed to hold the handle of the plastic water can with a clenched fist in pronation and the container hanging freely in front of the armchair or below the tabletop (Figure 1). The eccentric exercise group was instructed to lower the weight by flexing the wrist of the affected arm downwards and to lift it back again with the unaffected arm in three sets of 15 repetitions, in total 45 weight lowering manoeuvres, once daily. The concentric group was instructed to lift the weight by extending the wrist of the affected arm upwards and to lower it back again with the unaffected arm in three sets of 15 repetitions, in total 45 weight lifting manoeuvres, once daily. In both groups the load was increased weekly by one hectogram (one decilitre of water). The subjects were asked to report other competing treatments and were instructed not to use pain relieving or anti-inflammatory medication other than acetaminophen paracetamol.

Static stretching was performed in the seated position with elbow extension, forearm pronation, and wrist flexion with ulnar deviation. According to the patient tolerance stretch force was applied. This stretch position was held for duration of 30–45 seconds and was performed 3 times before and 3 times after the eccentric-concentric exercise portion of the treatment for a total of 6 repetitions.[9] There was a 30-second rest interval between each bouts of stretching.

Patients in Group B received eccentric –concentric exercise training with supinator strengthening. In the eccentric - concentric exercises of the wrist extensors combined with strengthening of supinator (Group B), eccentric - concentric training performed in the same way. Strengthening exercises of the supinator were performed with the elbow on the chair in full extension, the forearm in pronation, the wrist in mid - position and the hand hanging over the edge of the chair. From this position, patients supinated their arm slowly (Figure. 2) while counting to 15 using theraband, then returned to the starting position (pronation).

Figure 2. Supinator strengthening

Figure 1. Photograph showing exercise set-up With the patient seated in an armchair with Forearm support, holding a plastic container With a specified amount of water in the Affected arm, and performing exercise by Lifting and lowering the container by Extension or flexion of the wrist.

Figure 3. Measuring grip strength using hand dynamometer

Pain, function, grip strength, The Patient-Rated Tennis Elbow Evaluation Questionnaire (PRTEE) and dropout rate were measured in the present study. Each patient was evaluated at the baseline (week 0), 1 month (week 4), 2 month (week 8) and 3 month (week 12) and at 6 months (week 24).

Pain was measured on a visual analogue scale (VAS), where 0 (cm) was "least pain imaginable" and 10 (cm) was "worst pain imaginable". The pain VAS was used to measure the patient's worst level of pain over the previous 24 h before each evaluation, and this approach has been shown to be valid and sensitive of the VAS.[29]

Functional disability was measured using a The Patient-Rated Tennis Elbow Evaluation Questionnaire (PRTEE), formerly called the Patient- Rated Forearm Evaluation Questionnaire,[30] is a 15-item self reported questionnaire to measure perceived pain and disability in people with tennis elbow.[31] It has three subscales: pain, usual activities and specific activities. The pain subscale has five items about the intensity of pain during various activities. The specific activities subscale has six items tapping into the difficulty experienced while performing specific activities, like lifting a coffee cup. The four items in the usual activities subscale capture the difficulty experienced in performing usual daily roles like work and recreation.[31]The PRTEE has demonstrated sufficient clinical measurement properties. It has exhibited excellent test-retest reliability (ICC = 0.96) in a work-related tennis elbow sample [32] and an (ICC of 0.89) in a mixed work-related and non-work-related tennis elbow sample.[31]

In addition, function was measured by pain-free grip strength. Pain-free grip strength is defined as the amount of force each patient is able to generate with an isometric gripping action before eliciting pain.[33]force was measured in pounds with a Jamar hand dynamometer that had adjustable handles to accommodate different hand sizes. The arm was placed in a standardised position of elbow flexion, forearm mid prone position and internal rotation of the upper limb such that the palmar aspect of the hand faced medially with the upper limb placed by the patient's side. Patients were then instructed to squeeze the dynamometer handles until they first experienced pain and then to release their grip.[33] the attained grip force was subsequently recorded and the reading was not visible to the patient. Three measures of pain-free grip strength were recorded with a 30-s rest interval between each measurement, and the mean value of these repetitions was calculated. (Figure. 3)

A dropout rate was also used as an indicator of treatment outcome. Reasons for patient drop out were categorised as follows: (a) Unable to come treatment center, (b) Discontinued intervention, (c) Preference of specific treatment, (d) Travel reasons, (e) Unwillingness, (f) Health problem, (g) Meet the accidents, (h) Living so far, (i) Received additional neck treatment far away, (J) taken analgesic.

STATISTICAL ANALYSIS

Statistical analysis for the present study was done by using the statistics Software SPSS 16 version. For this purpose, data was entered into an excel spreadsheet, tabulated and subjected to statistical analysis. Various statistical measures such as mean, standard deviation and test of significance such as, paired t' test, One way Analysis of Variance (ANOVA) and multiple comparison tests were utilized for this purpose for all available scores for all the participants. Intra- group comparison of the pre interventional and post interventional outcome measures was done by using student paired 't' test whereas one-way ANOVA was used to measure the intergroup difference. Probability values less than 0.05 were considered statistically significant.

RESULT

Variables	GROUP A	GROUP B	P VALUE
	Mean (SD)	Mean (SD)	(p>0.05)
Age(years)	44.58 ± 5.5383	43.97 ±5.9313	0.602^
Duration(months)	15.14 ±2.2979	14.85 ± 2.0320	0.465^
Gender	16 Male=47.05%, 18 Female=52.95%	19 Male=55.88%, 15 Female=44.12%	
Affected side	22 Right=64.70%, 12 Left=35.30%	20 Right= 58.82%, 14 Left= 41.18 %	
Dominant side	30 Right=88.24%, 4 Left=11.76%	28 Right= 82.36%, 6 Left= 17.64%	

Table 1. Characteristics of the study population

Interpretation: The above table shows the mean and standard deviation of age in group A was 44.58 ± 5.5383, in group B was 43.97 ±5.9313.and mean and standard deviation of duration of symptoms in group A was 15.14 ±2.2979, in group B was 14.85 ± 2.0320. The demographic details (age; *p=0.602*, duration of condition; *p=0.465*) of groups were homogenous with *P>0.05(Table-I)*.

Level of significance P≤0.05

^- not significant

OUTCOME MEASURE	baseline	1st month	2nd month	3rd month	6th month	B-1	B-2	B-3	B-6	1M-2M	1M-3M	1M-6M	2M - 3M	2M - 6M	3M - 6M	P VALUE
VAS																
GROUP A	8.32 ±1.12	6.35 ±1.06	4.76±0.98	3.20±0.97	1.91±1.02	1.97±0.62	3.55±0.82	5.11±1.03	6.41±0.92	1.58±0.49	3.14±0.70	4.44±0.66	1.55±0.50	2.85±0.55	1.29±0.46	P <0.001 **
GROUP B	7.97 ±1.21	5.97±0.86	3.79±0.88	2.11 ±0.72	0.58 ±0.65	2.0±0.85	4.17±1.08	5.85±1.37	7.38±1.37	2.17±0.62	3.85±0.98	5.38±0.98	1.67±0.72	3.20±0.84	1.52±0.56	P<0.001**
P VALUE	P <0.001**	P <0.001**	P <0.001 **	P <0.001 **	P <0.001 **											
GRIP STRENGTH	baseline	1st month	2nd month	3rd month	6th month	B-1	B-2	B-3	B-6	1M-2M	1M-3M	1M-6M	2M - 3M	2M - 6M	3M - 6M	P VALUE
GROUP	10.55±2.	15.08	20.29±	26.44±	35.76±	4.52±1	9.73±1	1.58±2	2.52±3	5.20±1	1.13±2	2.06±3	6.14±1	1.54±3	9.32±3	

A	56	±2.56	2.83	3.75	4.55	.39	.94	.74	.84	.51	.48	.90	.77	.76	.35	P <0.001 **
GROUP B	12.20 ± 3.47	17.85 ±3.58	26.14± 3.58	35.52 ±3.71	43.94± 4.21	5.64±1 .51	1.39±2 .07	2.33±3 .14	3.17±3 .78	8.29±1 .56	1.76±3 .18	2.60±3 .88	9.38±2 .37	1.77±3 .14	8.41±1 .86	P<0.00 1**
P VALUE	P <0.001**	P <0.00 1**	P <0.001 **	P <0.001 **	P <0.001 **											
PRTEE score	baseline	1st month	2nd month	3rd month	6th month	B-1	B-2	B-3	B-6	1M-2M	1M-3M	1M-6M	2M - 3M	2M - 6M	3M - 6M	P VALUE
GROUP A	65 ± 7.29	54.08 ±7.33	42.52 ±7.20	31.48± 7.05	22 ±6.15	1.09±2 .49	2.24±3 .64	3.35±4 .24	4.30±4 .44	1.15±1 .92	2.26±2 .95	3.20±3 .47	1.10±2 .23	2.05±2 .98	9.48±1 .74	P <0.001 **
GROUP B	66.07± 6.56	52.86 ±6.60	38.94± 6.63	26.16± 5.74	14.72± 4.02	1.32±2 .73	2.71±4 .01	3.99±4 .27	5.13±4 .75	1.39±2 .34	2.67±3 .47	3.81±4 .46	1.27±2 .59	2.42±3 .98	1.14±2 .81	P <0.001 **
P VALUE	P <0.001**	P <0.00 1**	P <0.001 **	P <0.001 **	P <0.001 **											

Table 2. Comparison of VAS score, grip strength value and PRTEE score between baseline, 1st month, 2nd month, 3rd month and at 6th month.

Interpretation: the above result shows that there is stastically significant change in means of vas score, grip strength value and PRTEE score when compared from pre intervention to post interventions within groups with P <0.001**

Level of significance P≤0.05

** - highly significant

VAS	GROUP A	GROUP B	P VALUE	GRIP STRENTH	GROUP A	GROUP B	P VALUE	PRTEE SCORE	GROUP A	GROUP B	P VALUE
VARIABLES	MEAN DIFFRENCE	MEAN DIFFRENCE		VARIABLES	MEAN DIFFRENCE	MEAN DIFFRENCE		VARIABLES	MEAN DIFFRENCE	MEAN DIFFRENCE	
B-1	1.971	2	P <0.001**	B-1	-4.529	-5.643	P <0.001**	B-1	10.912	13.206	P <0.001**
B-2	3.559	4.176	P <0.001**	B-2	-9.735	-13.941	P <0.001**	B-2	22.471	27.132	P <0.001**
B-3	5.118	5.853	P <0.001**	B-3	-15.882	-23.324	P <0.001**	B-3	33.515	39.912	P <0.001**
B-6	6.412	7.382	P <0.001**	B-6	-25.206	31.735	P <0.001**	B-6	43	51.353	P <0.001**
1M-2M	1.588	2.176	P <0.001**	1M-2M	-5.206	-8.294	P <0.001**	1M-2M	11.229	13.926	P <0.001**
1M-3M	3.147	3.853	P <0.001**	1M-3M	-11.353	-17.676	P <0.001**	1M-3M	22.603	26.706	P <0.001**
1M-6M	4.41	5.382	P <0.001**	1M-6M	-20.676	-26.088	P <0.001**	1M-6M	32.088	38.147	P <0.001**

2M-3M	1.559	1.676	P <0.001**	2M-3M	-6.147	-9.382	P <0.001**	2M-3M	11.044	12.779	P <0.001**
2M-6M	2.853	3.206	P <0.001**	2M-6M	-15.471	-17.794	P <0.001**	2M-6M	20.529	24.221	P <0.001**
3M-6M	1.294	1.529	P <0.001**	3M-6M	-9.324	-8.412	P <0.001**	3M-6M	9.485	11.441	P <0.001**

Table 3. Comparison of mean difference in two groups (inter and intra-group)

Interpretation: this table shows comparison of mean difference in group A and group B. And multiple comparisons between different variables show highly significant difference. P<0.001**

Level of significance P ≤0.05

** - highly significance.

DISCUSSION

The purpose of the study is to compare the effectiveness of eccentric - concentric training of wrist extensors with static stretching and an eccentric - concentric training combined with supinator strengthening in the lateral epicondylitis.

There were two therapies implemented in this study, majority of the treatment protocol for the management of lateral epicondylitis ranges from Anti-Inflammatory Medication, Corticosteroid Injection, Electrical stimulation, LASER, acupuncture, counterforce Bracing or Splint, Ergonomics, Ultrasound, Iontophoresis, Phonophoresis, exercises (Flexibility, Strengthening and Endurance training), Manual therapy techniques, (e.g., Transverse Frictions, Joint mobilization and manipulation, Myofascial release, strain and counter strain techniques) etc.[34] Not single studies did comparison the effectiveness of eccentric - concentric training of wrist extensors with static stretching and an eccentric- concentric training combined with supinator strengthening the lateral epicondylitis.

When the intra-group means values of vas score, grip strength and PRTEE score were analyzed it was found statistically significant in both groups at baseline-1st month, baseline-2nd month, baseline-3rd month, baseline-6th month,1st month-2nd month, 1st month- 3rd month, 1st month-6th month, 2nd month-3rd month, 2nd month-6th month, 3rdmonth-6th month in both the groups. However, when inter-group comparison is done, group B showed highly statistical significance over group A. In the present study there is reduction in pain relief, improved grip strength, and reduced functional disability with the application of Ecentric-concentric training with supinator strengthening is contrast with the findings of previous studies.[35] It is the first study to date to comparing the effectiveness of ECT training with ECRB stretching and ECT training with supinator strengthening in LET management.

The results of this study demonstrate that both groups the ECT with static stretching (Group A) and ECT with supinator strengthening (Group B) experienced significant improvements in VAS score, function and Grip strength following 6 month treatment duration. The ECT with supinator strengthening (Group B) experienced greater outcomes for all variables in comparison to those receiving ECT with static stretching treatment.

A recently published trial assessed the effectiveness of eccentric training of wrist extensors and supinator strengthening in healthy subjects.[36] they found that the above combination produced a graded increase in surface electromyography activity in the healthy ECRB.[36] However; clinical studies are currently being conducted to determine if this approach is effective in the treatment of LET. Alfredson et al.,[37] were first proposed the eccentric training of the injured tendon. It is the most commonly used conservative approach in the treatment of tendinopathy. Malliaras and his colleagues [38] concluded that clinicians should consider eccentric – concentric loading alongside or instead of eccentric loading in Achilles And patellar tendinopathy. A Heavy Slow Resistance (HSR) program is recommended in the management of lower limb tendinopathy.[39,40] The HSR program was produced equivalent pain and function improvement (VISA) than the Alfredson eccentric program, but significantly better patient satisfaction at six month follow up. In the Achilles tendon, eccentric and HSR have recently been shown to yield similar clinical outcomes (VISA and patient satisfaction) at 1 year follow up. Based on the above findings, the HSR program can be recommended as an alternative to the Alfredson eccentric program lower limb tendinopathy rehabilitation. Studies determining the effectiveness of such as exercises at other tendinopathies such as LET are needed.

Standard eccentric exercises offer adequate rehabilitation for tendon disorders, but many patients with tendinopathies do not respond to this prescription alone.[44] the load of Eccentric exercises was increased according to the patients' symptoms because the opposite has shown poor results.[45]Eccentric exercises were performed at a low speed in every treatment session because this allows tissue healing.[5,37] Exercise programmes appear to reduce the pain and improve function, reversing the pathology of LET, [46–49] as supported by experimental studies on animals.[50] the way that an exercise programme achieves the goals remains uncertain as there is a lack of good quality evidence to confirm that physiological effects translate into clinically meaningful outcomes and vice versa.

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 tendinopathies .[84] Eccentric execution results in greater force production with less energy expenditure and less oxygen consumption compared to concentric execution. Nosaka et al [85] 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.[85] 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 tendinopathy patients. Once a muscle fatigues the tendon accepts the kinetic forces hence the reason tendinopathy injuries are observed in overuse repetitive type athletes. Main components comprising tendinopathy are angiofibroblastic hyperplasia which is an internal misalignment of collagen fibers. Each time the degenerative tendon is further worked it restarts the fibroblastic phase of healing laying down new Type III collagen further degenerate the components of a normal tendon. Another reason for positive outcomes could be the simple increase in tensile strength due to loading induced hypertrophy.[77] recent evidence suggests that eccentric actions may be more effective, but must be used with caution due to the common effect of muscle soreness. Traditional treatment techniques were not directly addressing this issue of compromised tensile strength. Progressively overloading the tendon overtime through eccentric exercises would then lead to an increase in tensile strength.[55] Moreover this treatment can be performed as part of a home program and does not involve continued medical supervision. In the light of these facts, we can conclude that the effect of therapeutic eccentric exercise training on stimulating tendon remodelling and producing muscular adaptive responses has led to reduction in pain and improvement in grip strength in persons with lateral epicondylitis.

In group B, statistically significant improvement in outcome measures from pre intervention to post intervention, and post intervention to follow up within the group could be because of effects of the eccentric concentric training and supinator strengthening exercise. Eccentric training results in tendon strengthening by stimulating mechano-receptors in tenocytes to produce collagen, which is probably the key cellular mechanism that determines recovery from tendon injuries. In addition, eccentric training may induce a response that normalises the high concentrations of glycosaminoglycans. It may also improve collagen alignment of the tendon and stimulate collagen cross-linkage formation, both of which improve tensile strength. The effects of exercise programmes for tendon injuries may be attributable to either the effect of stretching, with a lengthening of the muscle-tendon unit and consequently less strain experienced during joint motion or the effects of loading within the muscle-tendon unit, with hypertrophy and increased tensile strength in the tendon. Ohberg et al [49] believe that, during eccentric training, the blood flow is stopped in the area of damage and this leads to neovascularisation, the formation of new blood vessels, which improves blood flow and healing in long term which leads to reduces pain and improves functional capacity.[83]

Manias and Stasinopoulos[51] (quality rating of 75%, n ¼ 40 ;) studied the adjunctive effects of stretching alone versus ice and stretching when combined with eccentric exercise. The eccentric exercise program was performed for four weeks with five sessions a week and each session consisted of three sets of 10 repetitions. Patients achieved a decline in VAS pain score of about seven units in both groups. There were no significant differences in the magnitude of reduction between the groups at the end of the treatment or at the three-month follow-up. Because the adjunctive treatment groups both improved equally over time and the eccentric exercise program was identical, the effect of eccentric exercises alone could not be established.

In LET not only the ECRB but also the supinator may be involved[1] the exercise program should include not only for ECRB strengthening but also for supinator strengthening. Based mainly on clinical experience, supinator weakness in LET patients is commonly addressed as increasing pain, and decreasing functional ability and hand - grip strength. This means that the causes of LET may not be Limited to the ECRB. Functional impingement of the supinator due to altered joint mechanism and muscle imbalance can impair the stabilization of the elbow resulting in overcompensation of the ECRB.[52] this may lead to micro trauma of the soft tissue structures present at the lateral epicondyle thus causing symptoms of LET. It is reasonable that enhancements with gripping might have happened from a blend of enhanced motor control and upgraded muscular power of the supinator.[52] Changes in the supinator may lead to altered and compensatory changes in the ECRB that may overload the ECRB during repetitive movements, thus causing symptoms of LET. Using supinator strengthening loading, usual motion might have been returned, resulting in resolution of pain with actions and a return to painless gripping for the patient.[52]

Static stretching is defined as passively stretching a given muscle-tendon unit by slowly placing it in a maximal position of stretch and sustaining it there for an extended Period of time.[53,54] this maximal stretching position is determined by the moderate discomfort or pain that the patient experiences.[55,56,57] Static stretching exercises are Individualised by patient feedback as to the discomfort or pain experienced during the procedure. Therapists advocate static stretching exercises only for the injured tendon and not for all tendons in the anatomical region. In the case of LET, static stretching should be performed for the ECRB tendon, the site most commonly affected by LET.[9,55,58] The best stretching position result for the ECRB tendon is achieved with the elbow in extension, forearm in pronation, and wrist in flexion and with ulnar deviation, according to the patient's tolerance.[59] Recommendations for the optimal time for holding this stretching position vary, ranging from as little as 3 s to as much as 60 s.[60-64]Therapists believe that a stretch for 30–45 s most effective for increasing tendon flexibility.[53,55,57,58,59,63,65]

A static stretch should be repeated several times per treatment session, although the first stretch repetition results in the greatest increase in muscle-tendon unit length.[53,54,56,57,59,66]

Taylor et al [54]report that more than 80% of a muscle-tendon unit length can be obtained after the fourth repetition of a static stretch. Stanish et al,[58] Fyfe and Stanish,[65] and Stanish et al[55] claim that six repetitions of static stretching exercises should be performed in each treatment session, divided into an equal number of repetitions, with three before and three after eccentric training. Clinicians suggest a 15–45 s rest interval between each repetition.[53, 57] However, there is no information concerning the treatment regimen for static stretching exercises. As was described in the eccentric exercises section, this information is available for home exercise programmes based on other tendinopathies similar to LET and for a supervised exercise programme based on the authors' experience. Logically, it would seem that increasing tissue temperature before stretching would increase the flexibility of the muscle tendon unit; however, many therapists believe that stretching with or without a warm up yields the same results[.57, 62]

Exercise is rarely delivered as a treatment in isolation, with many RCTs studying a variety of exercise types in combination with other interventions. This review identified eight RCTs of sound methodological quality from five systematic reviews.[26,67-70,] that investigated the effects of isometric, isokinetic, concentric and eccentric exercises in LET. Three of the trials compared eccentric exercise to other treatments. Tyler et al (n = 21)[66] found a significant benefit of 9 (SD 2) sessions of eccentric exercise over 10 (SD 2) sessions of isotonic extensor exercises, with participants in both groups receiving a multimodal program of stretches, US, friction massage, heat and ice. The eccentric exercises produced greater pain relief and functional improvement, with nine of the 11 participants reporting at least 50% improvement in their pain following eccentric exercise, compared to three out of 10 reporting the same level of improvement in the comparator group. Viswas et al [71](n = 20) also found that a supervised program of eccentric exercises improved pain and function more than friction massage with Mill's manipulation at short-term follow-up. Similarly, a program of eccentric exercises with an elbow orthosis may provide greater global improvement at the end of treatment (6 weeks RR 4.7, 95% CI 1.1 to 19.8) but no difference in pain relief compared with an elbow orthosis alone (n = 37).[72] In contrast, a 3-month home program of eccentric exercises produced variable results when compared with a program of concentric forearm exercises, with both exercise interventions demonstrating significant improvement over short-term and long-term follow-up.[73] For exercise programs other than eccentric-only regimens, there was evidence from one RCT that isometric, concentric and eccentric exercises may be superior to US for pain relief (MD 21, 95% CI 1 to 41) and grip strength (MD 101 N, 95% CI 11 to 1914) at 8 weeks.[74] Compared to placebo US, Selvanetti et al[75] (n = 62) found a significant benefit after 4 weeks of eccentric exercises in combination with contract/relax stretching for pain relief at the end of treatment (MD, 95% CI 17 to 21). A 3-month home program of concentric/eccentric forearm exercises reportedly produced greater reductions in pain but not function, when compared with a wait-and-see approach.[73] However, one other study found no difference in pain and function outcomes at 6 weeks between concentric exercises, eccentric exercises and stretching (n = 81).[42]

Croisier et al [43] also showed benefits with a combined eccentric and concentric treatment; however, their program required the use of a specialized device that is not freely available in p people's homes. According to Ohberg L et al eccentric exercise may halt the growth of blood vessels in tendinosis and subsequently relieve some of the associated pain.[76] the results of our study are in accordance with the findings of a randomized controlled trial conducted by Roos.[77] 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 by Stasinopoulos.[78] Anyway the location of the threshold between safe and unsafe eccentric loading is unclear. Physical therapists must be aware of the continuum of factors that affect tendinous adaptation and ensure that the adopted protocol optimizes healing without producing harmful stresses. With respect to eccentric training for chronic lateral epicondylitis, Croisier et al[24] compared isokinetic eccentric wrist extensor training to standard physical therapy.[24] The effects of eccentric training on pain scores were very similar to the present study. Martinez et al.[42] found that eccentric exercise performed for 10 repetitions, three sets a session, once per day for six weeks with stretching showed a trend for improved pain and function in LE; but the effect was not statistically significant from that produced by a combination of concentric exercises with stretching or stretching alone. This study included 94 subjects and had a quality score of 32 out of 48 with a quality rating of 67% Isotonic (Concentric/Eccentric) Exercises Nine studies[41,42,43,79,80,81,82,83] ranging from level 1b to 2b using a total of 542 subjects examined the effect of isotonic eccentric exercises in the treatment of LET. The quality of studies evaluating isotonic exercises ranged from 58% to 92%. Most studies regarding the efficacy of exercise investigated eccentric strengthening exercises in Achilles tendinopathy. Based on experimental studies, eccentric strengthening exercise causes tendon strengthening by stimulating mechanoreceptors in tenocytes to produce collagen, which is the key cellular mechanism that determines recovery from tendon injuries.[47,49] Another reason for the positive effects of eccentric strengthening may be due to increased tensile strength in the muscle or decreased muscular strain during joint motion because of muscular lengthening.[37,41] On the contrary, several authors have called into question the idea that the mechanism that produces positive effects in Achilles tendinopathy may not be applicable to LET.

CONCLUSION

In conclusion, eccentric-concentric training group with supinator strengthening group is the most promising treatment approach in the management of lateral epicondylitis. The optimal protocol for this is needed to investigate. Further research is needed to find out which treatment strategy combined with eccentric-concentric training group with supinator strengthening group will provide the best results in the rehabilitation of tennis elbow tendinopathy. The current literature has shown great promise for the rehabilitation specialist to use eccentric-concentric training with supinator strengthening to restore function, decrease pain, increase grip strength and improve functional performance. Eccentric-concentric exercise should be an integral component of any lateral epicondylalgia rehabilitation program, not only because evidence suggests eccentric-concentric training with supinator strengthening work to be superior than ECRB with Stretching interventions but also because it is based off sound physiological principles. Although isokinetic training has been shown to be an effective treatment option, it may be too expensive or impractical for many facilities. Therefore, ECT Training with supinator strengthening is a practical treatment option to incorporate in the lateral epicondylalgia for use by the health care professional.

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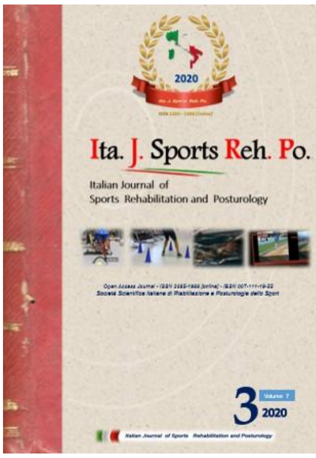

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Comparison of efficacy of the eccentric concentric training of wrist extensors with static stretching versus eccentric concentric training with supinator strengthening in patients with tennis elbow: A randomized clinical trial.

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Declaration of interest

The authors declare that they have no financial, consulting, and personal relationships with other people or organizations that could influence the author's work.

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