

# Effects of Eccentric Training of Wrist Extensors Versus Digital Latching & Lateral Rotation of Forearm in Lateral Epicondylitis - A Randomized Controlled Trial

<sup>1</sup>Shraddha More , <sup>2</sup>Rajeev Kumar Lal

<sup>1</sup>MPT (Musculoskeletal Disorders) SDM College of Physiotherapy, <sup>2</sup>Professor, Shri Dharmasthala Manjunatheswara University, SDM College of Physiotherapy

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## Abstract

**Background:** Lateral Epicondylitis (LE) is a tendon problem caused by repeated wrist movements and gripping. It is now seen as tendon wear and tear, not inflammation. Eccentric training helps tendon healing, while the newer DLaLR method corrects both muscle imbalance and joint mechanics, offering better pain relief and recovery.

**Objectives:** To compare the effects of therapeutic ultrasound and wrist extensors eccentric training versus therapeutic ultrasound and DLaLR in LE.

**Methods:** In a randomized controlled trial, 42 participants were equally divided into two groups using concealed envelope method. Group A (n=21) received therapeutic ultrasound with eccentric wrist extensor training, while Group B (n=21) received therapeutic ultrasound with DLaLR. Visual Analogue Scale (VAS), Patient Rated Tennis Elbow Evaluation (PRTEE), and pain-free grip strength (PFGS) were assessed at 0<sup>th</sup> day and after 4<sup>th</sup> weeks.

**Results:** There were no significant difference on VAS, PRTEE and PFGS on 0<sup>th</sup> day between the groups. Both treatment methods were found to be significantly effective for VAS ( $p = 0.0119$ , effect size = 0.83), PRTEE ( $p = 0.046$ , effect size = 0.62) and PFGS ( $p = 0.1159$ , effect size = 0.54) on 4<sup>th</sup> week. Group B showed more significant improvement ( $p < 0.05$ ) on 4<sup>th</sup> week as compared to group A.

**Conclusion:** DLaLR of forearm is found to be more effective than eccentric training of wrist extensor in LE.

**Key Words:** Lateral Epicondylitis, Digital latching & lateral rotation of forearm, visual analogue scale, Patient Rated Tennis Elbow Evaluation, pain-free grip strength.

## Introduction

Tennis elbow was first described by Runge<sup>1,2</sup> in 1873. Later on many other terminologies like tendonosis, lateral epicondylitis (LE), and

angiofibroblastic hyperplasia are given.<sup>3</sup> The annual prevalence rate varies between 1% and 3%. It is estimated that men have a prevalence of 1.0% to 1.3% and women have a prevalence of 1.1% to 4.0%.<sup>1,5</sup>

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**Corresponding Author:** Shraddha More (PT), OPD No 5, Orthopaedic Physiotherapy OPD Department, Sdm College of Physiotherapy, Manjushree Nagar, Sattur, Dharwad - 580009, Karnataka, India.

**E-mail:** moresshraddha22@gmail.com.

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LE refers to pain in lateral epicondyle owing to overuse of extensor muscles of forearm.<sup>4</sup> Today, LE is evident as a degenerative condition affecting extensor tendons that appear from lateral epicondyle, despite the word epicondylitis suggesting inflammation.<sup>6</sup> Forearm extensor muscles cross elbow, proximal and distal radioulnar joints, many of these muscles also cross wrist joint and few of them indeed cross metacarpophalangeal and interphalangeal joints of the fingers.

This condition is associated with chronic tear and degenerative changes in the origin of the extensor carpi radialis brevis (ECRB).<sup>4</sup>

Most common symptoms include tenderness and pain over lateral epicondyle during wrist flexion and extension, repetitive pronation and supination, weak grasp and functional disability. Stability of a joint depends upon congruency of articular surfaces, thickness of articular cartilage, orientation of fibres in ligaments; capsule and direction of muscular pull, which together facilitate free and controlled joint movements.<sup>7</sup>

Because the tendon absorbs the kinetic forces when a muscle fatigues, tendinopathy injuries are seen generally who are engaged in repetitious, high- intensity training. An internal misalignment of collagen fibers, known as fibroblastic hyperplasia, is one of the main components of tendinopathy. Each time the degenerative tendon is manipulated, the fibroblastic phase of healing begins again, laying down new Type III collagen that progressively degenerates the components of a normal tendon.<sup>8</sup>

Literature has set up connections between eccentric loading and positive effects in tendinopathy cases by converting hypertrophy, adding tensile strength and dwindling neovascularization. An eccentric contraction can increase the tendon's cell's stimulation, causing them to produce further collagen and increasing the tendon's resistance to force. In LE and other tendinopathies, neovascularization is thought to be a contributing element for pain.<sup>9</sup> Compared to concentric contraction, eccentric contraction produces further force while using lower energy and oxygen.<sup>11</sup>

According to recent research, eccentric movements might be more beneficial, but they should be employed precisely because they frequently results in muscle soreness.

Overcompensation of the ECRB may result from functional impingement of the supinator due to altered joint mechanics and muscle imbalance. This may lead to micro trauma of soft tissue structures present at the lateral epicondyle therefore causing symptoms of lateral elbow tendinopathy (LET). Changes in the supinator may result in altered and compensatory changes in the ECRB, which may overload the ECRB during repetitive movement, generating LET symptoms.<sup>11</sup>

The physiotherapy techniques, electrotherapeutic and non-electrotherapeutic modalities, has been recommended for the management of LET. These treatments have different theoretical mechanisms of action, but all have the same aim, to reduce pain and improve function. Many treatment options have been proposed for the rehabilitation of patients with LE, the effectiveness of which are largely unknown. These include exercise, massage, manipulation, taping, acupuncture, orthotic devices, ultrasound, activity modification, and rest.

According to clinical experience, supinator weakness in LE patient is generally addressed by reducing hand- grip strength, functional capacity, and increasing discomfort. This implies that the ECRB may not be the only factor contributing to LE.<sup>10</sup> The exercise regimen should serve to strengthen both ECRB and supinator as it may be involved in LE.

This study was conceptualized to explore and compare the effects of traditional eccentric wrist extensor training with a novel combined protocol-DLaLR of the forearm-aimed at offloading the ECRB, enhancing joint congruency, and restoring optimal forearm mechanics. The findings from this investigation offer valuable insights into more comprehensive and effective management strategies for individuals with LE.

## Methodology

### Study Design

A randomized controlled trial.

### Sampling Procedure

The sample size was calculated using G\*Power (v3.1.0) to achieve 95% power with a 5% alpha error and an effect size of 1.234, based on a mean difference of 4.176 and SD of 1.0. A total of 38 participants were required, with 10% added for dropout, making it 42 (21 per group).

Ethical clearance was obtained from the SDM Institutional Ethics Committee (Ref: SDMIEC/2024/734 Dated 16.05.2024), and the study was registered (CTRI/2024/07/070453).

The intervention was conducted at SDM Hospital Orthopaedic Physiotherapy OPD from July 2024 to June 2025.

### Participants

Participants were randomly divided into two groups by using opaque concealed envelope method where,

**Group A (n = 21):** received therapeutic ultrasound and eccentric training of wrist extensors.

**Group B (n = 21):** received therapeutic ultrasound and DLaLR of forearm training.

### Inclusion Criteria

Subject of either gender with LE diagnosed by orthopedic surgeon, Age from 35 to 60 years, and who did not receive any intra articular injections at elbow for Unilateral / Bilateral involvement, Cozen's sign or Mill's maneuver test positive were included for study.

### Exclusion Criteria

Any deformity in the affected upper limb or who has/had neurological problems affecting the involved upper limb or earlier episodes of LE of elbow treated surgically/ intra articular injection at

elbow or any fracture in the affected upper limb/s within past 6 months and individuals not willing to participate were excluded from the study.

## Intervention

### Exercise Protocol for Group A

1. The participants seated erect on chair with forearm supported on a pillow or on an adjustable table. Participant was instructed to hold water bottle (resistance as tolerated) with clenched fist and forearm in pronation with wrist extension. Then, was instructed to lower the weight by flexing the wrist of the affected arm downwards towards gravity and lift it back passively with the unaffected arm.
2. Progression was done by increasing the quantity of water in bottle.<sup>6</sup>

### Exercise Protocol for Group B

1. Starting position: Participant seated erect on armless chair with pillow on lap, shoulder maintained in neutral position, affected elbow in middle range of flexion, resting on pillow with the forearm pronation and the wrist in neutral position. The participant, performed digital latching [flexion of PIP & DIP joints of four fingers and IP joint of thumb within pain free ROM] and then laterally rotated (supinated) forearm within pain free ROM.
2. Progression was done by holding a notebook in hand same as above mentioned position of hand and digits latched harder and harder by pressing the notebook with painfree grip.

## Dosage

Participant performed 03 sets of 10 repetitions with 1 minute rest time in between the sets, twice daily for 4 weeks as home programme. A compliance sheet was provided to maintain daily record of exercises. Data of participants performing minimum of 45 sittings of exercise were included for data analysis.

## Conventional Therapy/ Therapeutic Ultrasound

Participants in both groups seated erect on chair, with shoulder abducted, elbow flexed wrist in neutral and pronated resting on pillow. After cleaning the affected area, ultrasonic gel was applied. The transducer head moved circular inslow motions for 6-7 minutes using 3MHz frequency at 0.8-1W/cm<sup>2</sup> intensity in pulsed mode 1:1 or 1:4.

### Outcome Measures

**Visual Analog Scale (VAS):** Measured pain.

**Functional Assessment:** Patient Rated Tennis Elbow Evaluation (PRTEE)

**Painfree grip strength:** Seahan hydraulic hand held dynamometer.

Outcome assessors were blinded for all outcome measures.

### Statistical Analysis

All analysis were performed using Statistical Package for the Social Sciences (SPSS) version 30.0. The tests for normality was done using Shapiro-wilk test for all the outcome measures which showed that the data in both groups was not normally distributed.

Data analysis for within group was done using Shapiro Wilk test and Wilcoxon Sign Rank test. To compare the difference between two groups, Mann Whitney U test was used. The statistical significance was considered as  $p < 0.05$ .

### Demographic Table

**Table 1. Comparison of gender distribution between group A and group B**

Gender	Group A	%	Group B	%	Total	%	P-value
Male	11	52.38	13	61.90	24	57.14	0.5329
Female	10	47.62	8	38.10	18	42.86	
Total	21	100.00	21	100.00	42	100.00	

Gender distribution was identical in both groups, with 57.14% males and 42.86% females. The chi-square

test showed no significant difference in gender distribution ( $p = 0.5329$ ).

**Table 2. Comparison of mean age between group A and group B using Independent t test. It revealed no significant difference in age between the groups ( $p = 0.6925$ ).**

Group	n	Mean (in year)	SD	SE	t-value	P-value
Group A	21	47.29	8.44	1.84	0.3983	0.6925
Group B	21	48.33	8.60	1.88		

$P < 0.05$ , SD- standard deviation, SE- standard error

Normality of VAS, PRTEE and PFG at all time points in both groups using Shapiro wilk test, indicates that they did not follow normal distribution ( $p < 0.05$ ). Hence, non-parametric test was used.

### Post Intervention Results

The study found that both Group A and Group B led to significant improvements in pain and function in patients with LE.

However, Group B showed significantly greater improvements in pain score as VAS, functional outcomes as measured by PRTEE and PFGS. Between group analysis showed significant differences in VAS ( $p = 0.0119$ ), PRTEE ( $p = 0.046$ ) and PFGS ( $p = 0.1159$ ) at 4<sup>th</sup> week, from day 0 to week 4, highlighting the superior effect of DLALR of forearm training on LE.

**Table 3. Within group analysis of VAS scores in group A and group B using Wilcoxon test.**

Groups	Time	Mean	SD	Mean Diff.	Effect size	% of effect	Z-value	p-value
Group A	Pretest	7.24	1.48					
	Posttest	4.38	1.8.3	2.86	1.93	39.47%	3.7017	0.0002*
Group B	Pretest	6.48	1.33					
	Posttest	2.95	1.60	3.52	2.65	54.41%	4.0145	0.0001*

p&lt;0.05\*

**Table 4. Within group analysis of PREET scores in group A and group B using Wilcoxon test.**

Groups	Time	Mean	SD	Mean Diff.	Effect size	% of effect	Z-value	p-value
Group A	Pretest	66.64	13.71					
	Posttest	46.57	12.70	20.07	1.46	30.12	4.0145	0.0001*
Group B	Pretest	67.62	17.24					
	Posttest	37.83	15.33	29.79	1.73	44.05	3.9798	0.0001*

p&lt;0.05\*

**Table 5. Within group analysis of Pain Free Grip Strength in group A and group B using Wilcoxon test.**

Groups	Time	Mean (in kg)	SD	Mean Diff.	Effect size	% of effect	Z-value	p-value
Group A	Pretest	22.49	8.91					
	Posttest	25.41	8.54	2.92	0.33	12.98	4.0145	0.0001*
Group B	Pretest	20.55	6.21					
	Posttest	29.00	4.67	8.45	1.36	41.11	4.0145	0.0001*

P&lt;0.05\*

**Table 6: Comparison of Group A and Group B with VAS scores at day 0 and 4 weeks treatment time points by Mann-Whitney U test**

Time points	Group A			Group B			Effect size	Z-value	p-value
	Mean	SD	Mean rank	Mean	SD	Mean rank			
Pretest	7.24	1.48	24.93	6.48	1.33	18.07	0.54	1.7986	0.0721
Posttest	4.38	1.83	26.29	2.95	1.60	16.71	0.83	2.5156	0.0119*
Difference	2.86	1.71	19.64	3.52	1.21	23.36	0.46	0.9685	0.3328

**Table 7. Comparison of Group A and Group B with PREET scores at day 0 and 4 weeks treatment time points by Mann-Whitney U test**

Time points	Group A			Group B			Effect size	Z-value	p-value
	Mean	SD	Mean rank	Mean	SD	Mean rank			
Pretest	66.64	13.71	19.81	67.62	17.24	23.19	0.06	-0.8805	0.3786
Posttest	46.57	12.70	25.29	37.83	15.33	17.71	0.62	1.9873	0.046*
Difference	20.07	10.70	17.29	29.79	16.20	25.71	0.72	-2.2137	0.026*

p&lt;0.05\*

**Table 8. Comparison of Group A and Group B with PFGS at day 0 and 4 weeks treatment time points by Mann-Whitney U test**

Time points	Control group			Experiment group			Effect size	Z-value	p-value
	Mean	SD	Mean rank	Mean	SD	Mean rank			
Pretest	22.49	8.91	22.74	20.55	6.21	20.26	0.26	0.64	0.5212
Posttest	25.41	8.54	18.50	29.00	4.67	24.50	0.54	-1.57	0.1159
Difference	2.92	1.61	12.26	8.45	3.29	30.74	2.25	-4.86	0.0001*

p<0.05\*

### Discussion

This randomized controlled trial compared two physiotherapeutic interventions for managing LE, eccentric training of the wrist extensors (Group A) and DLaLR of forearm training protocol (Group B). The primary aim was to evaluate improvements in pain, function, and grip strength using validated tools such as the VAS, PRTEE, and PFGS. Both groups demonstrated significant improvements over a four-week period. However, Group B, which received the DLaLR intervention, showed superior clinical outcomes across all outcome measures. This suggests that a combined therapeutic approach involving tendon offloading and joint realignment is more effective than traditional isolated tendon loading through eccentric training.

Eccentric training is widely regarded as a gold standard in tendinopathy rehabilitation. It involves the lengthening phase of muscle contraction, during which controlled loading is applied to the tendon. This process stimulates tendon healing through mechanotransduction, which enhances collagen synthesis and fiber realignment. In particular, eccentric loading reduces disorganized collagen (Type III) and promotes the formation of well-aligned, stronger Type I collagen. This structural improvement leads to greater tensile strength of the tendon and better resistance to stress during functional activities. The ECRB, the primary tendon involved in LE, benefits from such eccentric loads, especially as it is under constant strain during gripping and wrist extension tasks.

Eccentric exercises also contribute to neuromuscular control and proprioception, helping

restore functional movement. However, despite these benefits, eccentric training is not always well-tolerated by all patients, particularly in acute or highly irritable cases of LE. In such instances, directly loading an already inflamed tendon may exacerbate symptom and delay recovery. Moreover, eccentric training focuses predominantly on the tendon pathology and does not adequately address associated joint or muscular dysfunctions, such as radial head malalignment, supinator weakness, or abnormal forearm mechanics. This limitation causes the need for a more integrative approach like the DLaLR protocol.

The DLaLR protocol is a functional approach designed to address both the local pathology and associated biomechanical deficits of LE. It combines two core elements: digital latching and active forearm supination. The digital latching component involves concentric contractions of the finger flexors—namely the Flexor Digitorum Superficialis (FDS), Flexor Digitorum Profundus (FDP), and Flexor Pollicis Longus (FPL)—performed in a pain-free, neutral wrist position. This strategy enables patients to regain grip strength while minimizing direct strain on the symptomatic ECRB tendon. A progressive loading strategy using a notebook allowed for task-specific grip training that was adaptable based on the patient's pain tolerance. Importantly, this method strengthens the deep forearm musculature without compromising healing, making it especially suitable in the early phase of rehabilitation.

The key component of the DLaLR protocol—forearm supination—adds a biomechanical correction element that eccentric training lacks. Forearm supination is primarily facilitated by

the supinator and biceps brachii muscles. During this motion, the radial head moves proximally, anteriorly, and medially into the annular ligament, restoring its alignment with the humeroradial joint. This positional adjustment reduces mechanical stress on the lateral epicondyle and relieves pressure on the ECRB origin. In contrast, pronation leads to lateral and dorsal displacement of the radial head, increasing tension at the lateral elbow and aggravating symptoms. Thus, by repeatedly engaging the supinator and biceps, the DLaLR protocol promotes radial head realignment, enhances joint congruency, and reduces cumulative load on the injured tendon.

Anatomically, the coordinated contraction of FDS, FDP, and FPL contributes to proximal stabilization of the radius. These muscles create axial approximation and promote controlled movement of the radius relative to the ulna and humerus, supporting the radial head in its correct anatomical position. This dynamic stabilization is crucial in preventing micro-instability and correcting positional fault of the radial head—factors often overlooked in traditional LE rehabilitation but essential for full recovery. Moreover, by training the muscles responsible for gripping and supination in synergy, the DLaLR protocol respects functional movement patterns, leading to better long-term outcomes.

Another notable aspect of DLaLR is that it aligns with pain and functional rehabilitation principles. Rather than provoking pain through direct loading, it facilitates muscle activation in a pain-free range, which helps desensitize the nervous system and improve movement confidence. It also prevents joint laxity, abnormal movement patterns, and compensatory muscle inhibition by restoring both muscle strength and joint mechanics. This dual approach ensures a more comprehensive and holistic recovery.

Clinical results from this study substantiate these theoretical advantages. Patients in Group B showed greater improvement in all outcome measures, including reduced VAS scores (indicating lower pain), improved PRTEE scores (indicating better function),

and higher PFGS values (indicating stronger, pain-free grip). These findings support the idea that LE is not merely a tendinopathy but also involves complex joint and neuromuscular dysfunctions. Addressing these through a combination of tendon offloading and joint realignment—as done in the DLaLR protocol—results in faster and more complete recovery. The results of this study align closely with those of another article that followed a similar protocol. Both studies demonstrate consistent findings. The outcomes are statistically significant. This strengthens the reliability and relevance of the observed effects.<sup>8</sup>

In conclusion, while eccentric training remains an evidence-based, effective treatment for LE, it may not be sufficient for all cases, particularly those involving biomechanical or neuromuscular deficits. The DLaLR protocol offers a superior approach by integrating tendon offloading, digital coordination, and forearm realignment. Its multi-joint, task-specific, and pain-free strategy addresses both the primary pathology and secondary dysfunctions, leading to better patient outcomes. Based on both biomechanical rationale and clinical evidence, DLaLR should be considered a more comprehensive and effective intervention for managing LE.

### Limitations

1. The study involved a relatively small sample size, which may restrict the generalizability of its findings.
2. All the participants were recruited from only one hospital, potentially introducing selection bias.
3. This study focused only on short term follow up.

### Conclusion

- Findings of this study suggests that both the groups A and B showed statistically significant difference in reduction in pain on VAS, and increase in function on PREET and painfree grip strength at 4<sup>th</sup> week.

- Group B showed more effective in reduction in pain on VAS, increased function on PREET scale and PFGS as compared to group A at 4 weeks. Which explained DLALR is more effective in managing LE as compared to eccentric training.

### Future Scope

1. It should provides a structured comparison between a standard and an expanded exercise protocol for LE management.
2. Future studies should be conducted with larger sample sizes to enhance the reliability of the study and statistical power.
3. A multi-center study should be considered so that the results can be generalized to large population and clinical settings.
4. Future studies should aim to find the long term effects of DLALR of forearm to evaluate the sustained effects of the intervention over time

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