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Effect of tendon neuroplastic training on pain and functional disability in chronic lateral epicondylitis patients at the end of 6 weeks: A randomised control trial

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Abstract
Purpose: The study was conducted to identify the therapeutic effect of tendon neuroplastic training (TNT) along with conventional treatment for the treatment of chronic lateral epicondylitis patients. The study would reveal the superiority of treatment option available when compared to the control group.
Objective: To find out the effect of tendon neuroplastic training on pain, functional disability at the end of 6 weeks, to find the effect of conventional treatment on pain and functional disability at the end of 6 weeks and compare both of them.
Method: Subjects were selected on the basis of inclusion and exclusion criteria. After taking informed consent they were allotted in two different groups namely A and B according to the computer generated random list. Group A participants were given experimental treatment of tendon neuroplastic training on three non-consecutive days per week for 6 consecutive weeks along with conventional treatment and Group B participants which is the control group were given only conventional exercises which was performed daily.
Study design: The study design is experimental and conducted by using randomised control trial.
Result: The study showed that the experimental group exercises viz. tendon neuroplastic training along with baseline conventional, was found out statistically significant with $p < 0.05$ than conventional treatment alone.
Conclusion: This study concludes that tendon neuroplastic training is more effective over control group exercises on pain and functional disability at the end of 6 weeks as assessed by patient rated tennis elbow evaluation.

Keywords: lateral epicondylitis, tendon neuroplastic training, patient rated tennis elbow evaluation

1. Introduction

Lateral epicondylitis (LE) is a condition which describes an overuse injury associated to common extensor origin usually caused by excessive quick, repetitive movements of wrist and forearm [1]. The word epicondylitis suggest inflammation but today it is clear that Lateral epicondylitis is a degenerative disorder that comprises the extensor tendons originating from the lateral epicondyle [2]. Nirschl classified lesions secondary to tendinous micro trauma in cases of lateral epicondylitis, into four stages. The first stage is inflammatory, reversible and without pathological alterations. The second stage is characterized by angiofibroblastic degeneration. The third stage is characterized by tendinosis associated with structural alteration (tendon tearing). In the fourth stage, in addition to the latter alterations, fibrosis and calcification are present. Lateral epicondylitis has a prevalence of about 1-3% general population every year and peak prevalence in 30 to 60 years of age [3].

Most common symptoms include tenderness and pain over the lateral epicondyle during wrist flexion and extension activities or repetitive pronation and supination, weak grasp and functional disability. Many conservative options are available including rest, bracing, cryotherapy, cyriax, Mulligan Mobilization, instrument assisted soft tissue mobilization etc.

Despite the myriad of treatment options available up to 10% cases still continue to experience long term pain and functional disability. Anatomically, pathological tendons experience an increase in tenocyte cell size and number of disorganization of collagen, increased proteoglycan and water content but recent evidence has also demonstrated alterations to motor cortex that is changes in corticospinal excitability and short interval cortical inhibition.

Tendinopathy rehab including Lateral epicondylitis mostly focuses on the tension strength deficit and pain reduction by modalities and cryotherapy. Tendon neuroplastic training (TNT) is a combination of resistance exercise and metronome-based training which focuses not only on the tensile strength component but also combats the cortical excitability and inhibition which is the CNS sequelae of chronic lateral epicondylitis. Baseline conventional treatment includes static stretching of wrist flexors extensors, radial and ulnar deviators and strengthening exercises using an elastic band. Therefore, the objective of the study was to find out the effect of tendon neuroplastic training and conventional treatment as one experimental group and other control group receiving conventional treatment alone carrying out a superiority randomized control trial.

2. Materials and Methods

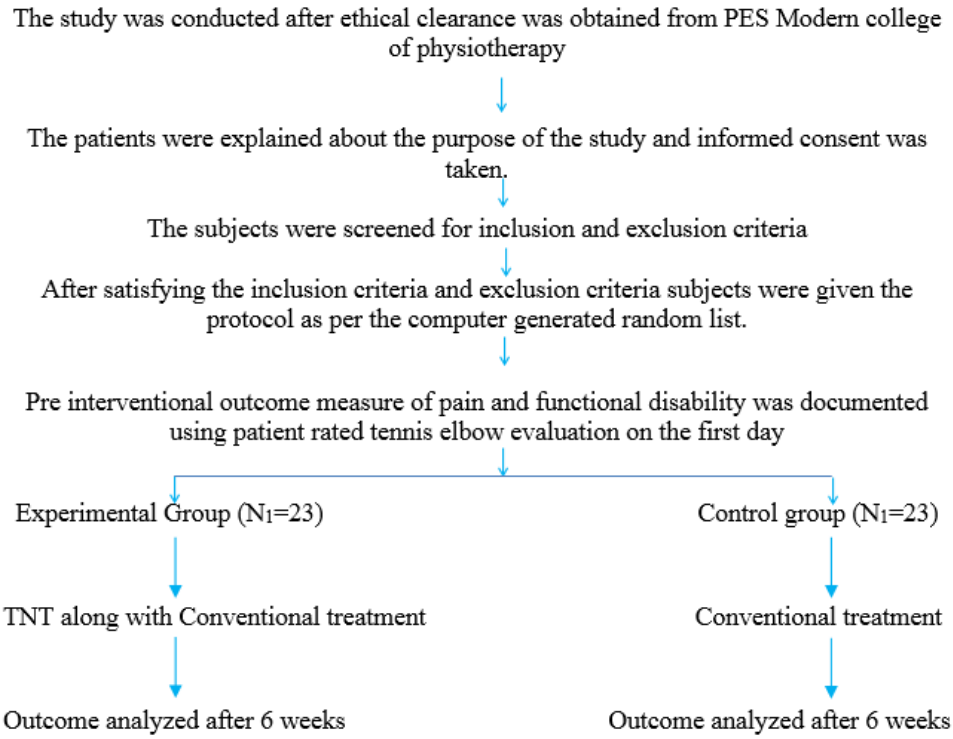
Materials

1. Metronome app

2. Weight cuff / Dumbbell
3. Chair
4. Pillow
5. Pen and paper
6. Towel roll
7. Elastic Band
8. Stick

Methodology

1. Study Type – Experimental study
2. Study Design – Randomized control trial
3. Study population – general and occupational population
4. Sample size – 46
5. Sampling method – Purposive sampling
6. Sampling design – computer generated random sampling
7. Study setting – Various hospitals and clinics in and around Pune city.
8. Duration of study – 6 months
9. Treatment duration- 6 weeks



Flow chart 1: Flow Chart of the phases of Randomized Controlled Trial

2.1 Inclusion and exclusion criteria

2.1.1 Inclusion criteria

1. Age group between 30-60 years
2. Both males and females.
3. Patients with tender point over common extensor origin.
4. Chronic lateral epicondylitis patients with ≥ 3 months.[7]
5. Mills and cozens special test for LE positive.
6. PRTEE 13-81/100 [9]
7. Common flexor and extensor origin of wrist, radial and ulnar deviators MMT: ≥3 and <5.

2.1.2 Exclusion criteria

1. Prior elbow surgeries
2. Patients with auditory and cognitive impairments.
3. Patients on steroid or analgesics for present complaint.
4. Dislocation of elbow complex.
5. Tendon rupture grade
6. Uncooperative patient
7. Patients having cervical radiculopathy (C5-C6) mimicking like that of lateral epicondylitis.

2.2 Outcome measures

2.2.1 Patient Rated Tennis Elbow Evaluation (PRTEE)

The PRTEE allows patients to rate their levels of tennis elbow pain and disability from 0 to 10, and consists of 2 subscales:

1. Pain subscale (0 = no pain, 10 = worst imaginable) (ICC= 0.94) Pain-5 items

2. Function subscale (0 = no difficulty, 10 = unable to do)

Specific activities - 6 items (ICC=0.93)

Usual activities - 4 items (ICC=0.85)

Standardized responsive mean (SRM) was higher (2.1) when compared to other outcome measures such as DASH, VAS, Upper Extremity Functional Scale.

2.3 Procedure

Subjects were selected for the study based on the inclusion and exclusion criteria. Procedure was explained to them. Pain and functional disability was assessed using PRTEE scale was recorded before commencing the exercise program.

Subjects were thoroughly explained about the exercise programme and the exercises were done under supervision.

2.3.1 Group A (Experimental group) [10]

Patients according to the random list were given tendon neuroplastic training. This protocol was performed on three non-consecutive days per week for 6 consecutive weeks. The exercise involves isolated wrist flexion and extension

with a dumbbell or sandbag paced to an external auditory cue using metronome. The patients will listen to the sound and track the movement of the metronome with their eyes, as pacing to these types of external cues has been shown to modulate corticospinal excitability. The pace of the metronome was set to 60 beats per minute such that each beat was three seconds apart. This is allowed a 3 seconds concentric and 4 seconds eccentric phase. 4 sets of 8 repetitions were completed with 2 minutes rest in between each set. The patients were instructed to begin with a three to five pound weight and to ensure that this will not cause pain to exceed a severity of 5/10 during exercise. Gradual progression of weights was attempted every week within tolerance.
Weights were increased by 2.5% (0.25-1Kg) every week for progression. If pain was experienced during an exercise or if participants were not able to complete their repetitions with proper execution (e.g., shaking during the contraction), they were instructed to lower the weight for the following repetitions and complete the entire session.

Table 1

Week	Sets	Reps	Tempo	Weight (LBS)
1	4	8	3sec up - 4sec down	3
2	4	8	3sec up - 4sec down	3
3	4	8	3sec up - 4sec down	3
4	4	8	3sec up - 4sec down	5
5	4	8	3sec up - 4sec down	5
6	4	8	3sec up - 4sec down	5

2.3.2 Group B (Control) [1, 11]
Patients according to the random list were given conventional exercises protocol for 6 consecutive weeks.
The exercises started with slow fist-clenching, resisted wrist movements, and wrist rotations with a stick (step 1), followed by movements against a band (step 2)and two-way resisted wrist rotations and pressing hands against a wall (step 3)**.** The patients performed the exercise programme under supervision. Each programme included ten repetitions in three series for each exercise. The fourth step was a versatile occupational training programme. Every exercise period ended with stretching for at least 30 seconds in both flexion and extension and each individual exercise movement was done slowly while the patient counted till eight.
Only when a patient will be able to perform an exercise step, he or she was allowed to perform next step.

Conventional exercise protocol: progressive exercise programme
Step 1
Clenching fist strongly
Resisted wrist extension
Resisted wrist flexion
Wrist rotation with a stick
Towards the little finger
Towards the thumb to flexion and extension
End: stretching at least 30 seconds

Step 2
Exercises against an elastic band for:
Wrist extension
Wrist flexion
Wrist radial deviation
Wrist ulnar deviation
End: stretching 30 seconds (as in step 1)
10 x 3 series, several repetitions daily

Step 3
Combined wrist rotary movements
Using eg table top as a support
Upwards, resisted from below
Towards the little finger
Towards the thumb
Downwards, resisted from above
Towards the little finger
Towards the thumb
Pressing hands against a wall
End: stretching 30 seconds
10 x 3 series, several repetitions daily

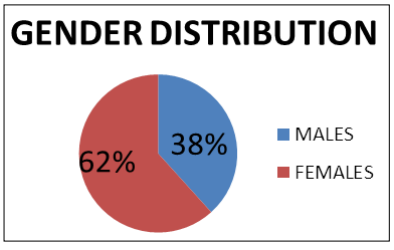
Step 4
An occupational training programme, including:
Soft ball compressing exercises
Transferring buttons from cup into another
Rotating hand on a table, in both directions, etc
Twisting a towel into a roll 10
End: stretching 30 seconds
This program can be performed together with one of steps 1-3.

Deep transverse friction massage (DTFM) [12]
Friction massage was carried out with both thumbs distal to lateral epicondyle with direction of the movement being transverse, across the fibers of common extensor origin. Movements of the thumbs were of small amplitude and regulated pressure throughout the treatment was given.
DTFM increases tendon extensibility and mobility and is accompanied by increased functional performance.
Duration: Daily for 10 minutes

2.4. Data and statistical analysis
Statistical analysis was conducted using SPSS v20™ for Windows.
All the test results are shown in tabular as well as graphical format to visualize the statistically significant difference more clearly. In the entire study, the p value less than 0.05 are considered to be statistically significant. The intra group comparison of pre and post variables was done using Wilcoxon test for both group A and group B. The inter group comparison for group A and group B was done using Mann Whitney µ test.

Table 1: Shows the number of males and females in the study

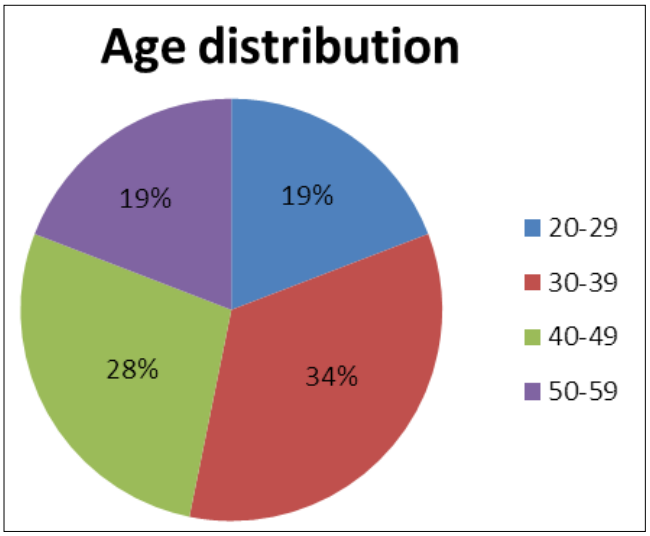
Gender	Total
Males	18
Females	29



Graph 1: Shows gender distribution amongst all participants.

Table 2: Age group distribution

Age			
20-29	**30-39**	**40-49**	**50-59**
9	16	13	9

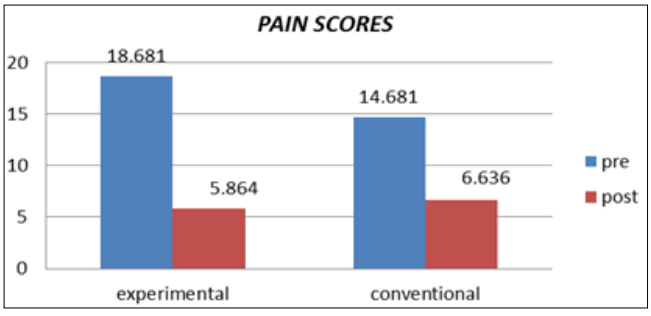


Graph 2: Shows age distribution amongst all participants

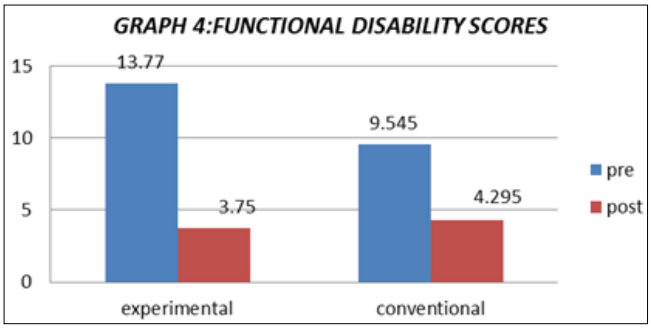
2.4.1 Intra group comparison

Table 3: Shows the intra group interpretation for pain, functional disability and total scores mean SD, Z value and p value using patient rated tennis elbow evaluation scale

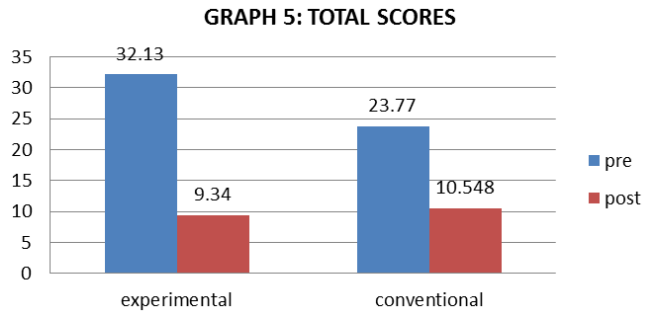
		Mean ± SD	z-value	p-value	Significance
Conventional					
Pain	Pre	14.681 ± 3.239	-4.127	0.001	Statistically significant
	Post	6.636 ± 2.478			
Functional disability	Pre	9.545± 3.340	-4.118	0.001	Statistically significant
	Post	4.295± 1.628			
Total scores	Pre	23.77± 4.12	-4.111	0.001	Statistically significant
	Post	10.548± 4.507			
Experimental					
Pain	Pre	18.681± 4.373	-4.117	0.001	Statistically significant
	Post	5.864± 2.455			
Functional disability	Pre	13.77± 5.054	-4.112	0.001	Statistically significant
	Post	3.75± 2.305			
Total scores	Pre	32.13±8.295	-4.109	0.001	Statistically significant
	Post	9.341±3.442			



Graph 3: Intra group comparison of pre and post pain scores



Graph 4: Intra group comparison of pre and post functional disability scores

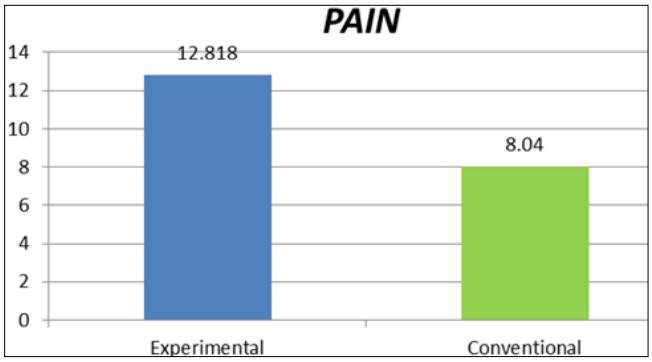


Graph 5: Intra group comparison of pre and post total scores

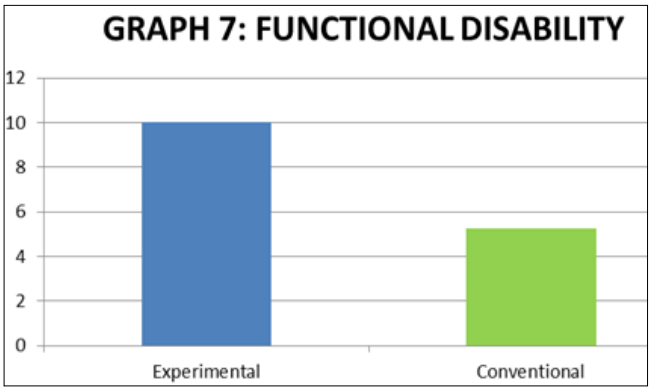
2.4.2 Inter group comparision

Table 4: Shows the inter group interpretation for pain, functional disability and total scores mean SD, Z value and p value using patient rated tennis elbow evaluation scale

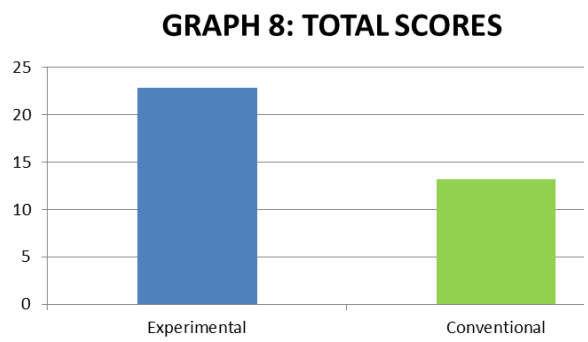
Difference Mean	Experimental	Conventional	Z value	P value	Significance
Pain	12.8182	8.0455	-4.428	0.001	Statistically significant
Functional Disability	10.0227	5.2504	-4.235	0.001	Statistically significant
Total scores	22.7954	13.2251	-5.476	0.001	Statistically significant



Graph 6: Inter group comparison difference between pain scores



Graph 7: Inter group comparison difference between functional disability scores



Graph 8: Inter group comparison difference between total scores

2.5 Ethical issues

Entire process of this research project was done by following the guidelines of Maharashtra University of Health Science. Synopsis proposal including procedure and methodology was approved by the Ethical committee of PES modern college of Physiotherapy at institution level. The safety of the participant was ensured by the researcher and strict confidentiality was maintained regarding patient information, their condition and the treatment.

2.6 Informed Consent

The researcher obtained informed consent from all the participants within the study. All the participants were explained about the study and the nature of the assessment and treatment. They were given the liberty to quit being part of the study at any time if they wish to without having to give any reason for doing so. Participants were free to ask any queries regarding their condition to any of the superior staff or doctor.

3. Result

Inter group comparison of Groups A and B was done by comparing the difference in the mean values. The mean difference value of pain of group A and B are 12.8182 and 8.045 respectively. Graph 6 shows the representation of comparison of pain between experimental and control group and since the mean difference of experimental group is greater than the control group, it denotes experimental group is more effective than control group exercises to alleviate pain which can be interpreted on the graph.

The mean difference value of functional disability of group A and B are 10.022 and 5.250 respectively. Graph 7 shows the representation of comparison of functional disability between experimental and control group and since the mean difference of experimental group is greater than the control group, it denotes experimental group is more effective than control group exercises to reduce functional disability which can be interpreted on the graph.

The mean difference value of total scores of group A and B are 22.795 and 13.225 respectively. Graph 8 shows the representation of comparison of total scores between

experimental and control group and since the mean difference of experimental group is greater than the control group, it denotes experimental group is more effective than control group exercises to improve the total scores on prtee scale which can be interpreted on the graph 8.

According to the data analysis, the experimental group exercises viz. tendon neuroplastic training along with baseline conventional was found out to be more effective and statistically significant with $p<0.001$ than conventional treatment alone.

4. Discussion

The present study was done to see the effect of tendon neuroplastic training on pain and functional disability in chronic lateral epicondylitis patients at the end of 6 weeks which was assessed by patient rated tennis elbow evaluation scale.

For the study 46 subjects were divided in 2 different groups named A and B. The subjects were allotted the group by computer generated random list. Group A patients received tendon neuroplastic training along with conventional training and group B received conventional treatment only. Patients with chronic lateral epicondylitis were selected according to the inclusion and exclusion criteria. The treatment protocol was conducted in different hospitals, clinics, gyms and sports academy across the city for 6 weeks. Pretreatment data was collected by using patient rated tennis elbow evaluation which consisted both the components pain and functional disability. The treatment protocol was given for 6 weeks. Post treatment same measures were recorded and the result was drawn out.

According to the results, the study demonstrates the experimental treatment i.e. TNT and conventional treatment was more effective to alleviate pain and functional disability than conventional treatment alone.

Tendon neuroplastic training combats lateral epicondylitis by not only sufficing the tension strength deficit but also addresses the cortical excitability and short interval cortical inhibition. TNT comprises of strength training on the audiovisual cues of metronome. Chronic pains leads disruption of the corticospinal excitability and Short interval intracortical inhibition and thus act as the supporting fact for the reason of pain and functional disability According to Lorimer Moseley (2012), sensitization is simply the adapting mechanism of our body or the biological system according to use and biological advantage. After the pain stimuli there can be 2 possibilities to alleviate pain: peripheral and central sensitization. Excitability of the motor cortex can be suppressed during muscle pain.

Sensitization occurs in the spinal cord and supraspinal centers. Central sensitization activates the spinal nocioceptors and offers biological advantage by increasing the sensitivity of peripheral inputs. This in turn increases the likelihood of tissue healing and minimizes the risk of secondary injury. But over the time this protective mechanism of sensitization loses the adaptive value which leads to persistent chronic pain. Chronic pain leads to reduction in the corticospinal excitability and increase in the Short interval intracortical inhibition. The corticospinal excitability is responsible for increasing the sensitization which is the protective response of the body to prevent further injury. Short interval intracortical inhibition is responsible for analgesia so that the normal day to day function does not get hampered due to pain. Body schema is the sensorimotor representation that guides action. It is the representation of the body in space in relation to the environment and to each other. Large evidence shows that chronic pain is associated with disruption of a range of body related cortical presentation (body schema) and this disruption leads to maladaptive neuroplastic changes and contributes to, or maintains chronic pain. Pearce and kidgell *et al* (2010) suggests that skill training that utilizes visual or audible cues is critical for inducing use dependent plasticity within the premotor area, M1, supplementary motor cortex and sensorimotor cortex [15]. Synchronizing the training to an audiovisual cue could be the key to modulate the corticospinal excitability which is a measure to alter the motor control [16]. Thus the maladaptive neuroplastic changes undergo neuroplasticity with the help of metronome based strength training which changes the disrupted cortical representation by addressing the corticospinal excitability and combats the chronic pain of lateral epicondylitis patients. Our results are in account with Ebonie Rio *et al*, as they reported that tendon neuroplastic training was found out to be effective in patellar tendinopathy patients. They used both, isometric and isotonic method, found to alleviate pain within 4 weeks of intervention with the same parameters.

Conventional treatment comprises of stretching and strengthening using stick, elastic band, body weight loading, soft ball compression and occupational and functional exercises.

International journal of health science and research published a research paper which lead to the following mechanism. Loadingleads to increase in the production of dense collagenous scar in the area of the attachment. It improves collagen alignment of the tendon and stimulate cross linkage formation both leads to increase in the tensile strengthand formation of new fibrous tissue at the musculotendinous unit, making it more resistant to damage. Progressive Eccentric training also leads to lengthening of the muscle-tendon unit, which might increase the tensile strength of the tendon and stimulates mechanoreceptors in the tenocytes to produce collagen which is the key cellular mechanism that determines recovery from tendon injuries. This leads to healing without traumatization thus pain is eliminated [4, 6].

During the treatment of Group A patients, gradual Progression was done after the patients were able to lift weights 4 sets of 8 reps effortlessly. (1kg per week).Out of Group A patients, two of them experienced soreness after the initial 2 days of treatment and required icing post the treatment protocol. This may be probably due to the lack of exercises in their daily sedentary life prior to the treatment protocol. Few patients felt clinically significant reduction in pain and functional disability within 4 weeks and few required complete 6 weeks for the same effect. This may be due to the differences in pain intensity prior to the treatment. Both of the groups were given conventional baseline treatment. Static stretching of wrist flexors and extensors were given before and after each step of the protocol. The elastic band exercises with the patient seated on a chair and plinth support under the elbow. Progression of the elastic band was done gradually from yellow-red to green as they were able to carry out all wrist ranges and supination and pronation comfortably without any jerky quick recoil of the band during the eccentric activity. Wringing exercise was done using Turkish towel. Patients were asked to do loading

i.e. pushups according to their tolerance. The protocol started gradually from wall pushups up to proper horizontal pushups. In the later stages of the treatment protocol they were started with the occupational and functional activities such as writing, typing, playing, gym, washing clothes according to their tolerance and a large group of people were able to commence with activities with minimal to no functional disability. In this study the researcher found out that experimental and conventional group both were successful in reduction of pain and functional disability. But after comparison of both the groups experimental group was found out to be superior than the control group for reduction of pain and functional disability in chronic lateral epicondylitis patients.

5. Limitations

1) The study was done using a small sample size.

6. Future scope

1) Further studies must be done using a large sample size
2) The same treatment protocol can be used for a shorter duration and the effect of the intervention can be assessed.
3) A large group of individuals within sample size were found out to be teachers. Therefore, a study can be done using this population.

7. Conclusion

This study concludes that tendon neuroplastic training is more effective over control group exercises on pain and functional disability at the end of 6 weeks as assessed by patient rated tennis elbow evaluation.

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