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Designing A Customized Device for Eccentric Exercise Training of Wrist Extensor Muscles in Individuals with Tennis Elbow

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Reshma Pillai1, Dr. Namrata Kadam2
Intern, Krishna College of Physiotherapy1
Assistant Professor2, Department of Paediatric Neurosciences, Krishna Institute of Medical Sciences, "Deemed to be University, Karad

Keywords:
tennis elbow, eccentric training, device, wrist extensors.

Abstract
Background:
Tennis elbow is a common soft tissue injury most commonly seen in sports or work related activities. Eccentric exercise is a type of strengthening exercise that has been used quite frequently in reducing pain and to improve function in the involved muscles. This particular study focuses on designing a device that is based on principle of eccentric exercises and its role in increasing strength in the muscles by adding resistance. This study is to determine the efficiency of the device in terms of eccentric training.
Method:
A random sampling method was used to allocate the patients. A sample size of 50 individuals diagnosed with tennis elbow were included in the study. A protocol for eccentric exercise was set in which the patient was asked to perform the exercise with the help of a device 3 times in a day for 4 days in a week and the entire protocol was for 4 weeks.
Result: The study has proven to be very significant with a P value of <0.0001. Interpretation of all the outcome measures have shown P value of 0.001 with the help of paired t test. Later the results were tabularized by and put into the form of graphical format.
Conclusion: This device based on principle of eccentric exercises is significantly effective in the case of tennis elbow as it specifically focuses on eccentric contraction.

1. Introduction

Tennis elbow is a condition commonly associated with work or sports related over-activities. The main cause of tennis elbow is said to be impaired tendon healing which leads to pain over the lateral epicondyle of the humerus.[1] The most commonly affected structure is extensor carpi radialis brevis. Tennis elbow usually affects the dominant arm and the prevalence usually rises at the age group of 30-60 years. It is a self – limiting condition which persists no longer than 12 months.[2] The chief complaint of tennis elbow is pain which is present over the outer aspect of the elbow and the pain is aggravated while performing wrist extension in radial deviation.[3] Other symptoms include tenderness over the region of the radio-humeral gap, discomfort while performing resisted extension of wrist.[3]

Anatomy

The elbow joint is a type of complex hinge joint with movement of flexion and extension[4]The motion of supination and pronation is performed by proximal and distal radio-ulnar joints. The articulating surfaces of trochlea and capitulum are formed by two condyles of the distal humeurs. Above the condyles are the medial and lateral condyles. The medial epicondyle is an attachment site of ulnar collateral ligament and is an origin point of the forearm flexor- pronator group. The lateral condyle which is located just above the capitulum is an origin point of extensor- supinator group. Tennis elbow is involved with the lateral area.[5,6] The lateral epicondyle is not as prominent as the medial epicondyle. The proximal aspect of the lateral epicondyle is formed by the supracondylar ridge. The ridge that is easily palpable separates the long head of triceps on the posterior surface from the brachioradialis,

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extensor carpi radialis longus anteriorly and extensor carpi radialis brevis.[5,6]

The elbow joint gets its stability from the bony anatomy and the ligaments which are the specialized thickenings of joint capsule [5,6]The joint capsule is lined by the synovial membrane but is separated from the capsule by fat pads opposite to olecranon, coronoid and radial fossae. Between the capitulum and the radial head there is a projection of a fold of synovial tissue. This synovial fold forms the "meniscus" of the radio-humeral joint. Lateral epicondylar pain is said to be the cause of synovitis of the fold of the tissue[5,6]The radio-humeral bursa that lies deep to the common extensor origin and below the extensor carpi radialis brevis and superficial to the radiohumeral capsule is involved in the etiology of lateral epicondylitis.[7,8]

Treatment

Intervention of tennis elbow focuses on the aspects of relieving pain , controlling inflammation, promoting healing m improving local and general fitness and controlling force loads[9]Various therapeutic modalities are used in the treatment of tennis elbow such as cold application, heating modalities , SWD , Electrical stimulator.[10,11, 12] Exercise program is also included in the treatment of tennis elbow.[13,14,15]The main components of exercise program are stretching and strengthening exercises to make the tendons flexible.[16,17,18,19,20]Three forms of musculotendinious contractions that strengthen soft tissue structures are i)isometric, ii)concentric and iii)eccentric.[21,22,23] For tennis elbow , eccentric exercise should be performed for the extensor tendons of the wrist most commonly extensor carpi radialis tendon.

Eccentric exercise works on three principles: i) load, ii) speed and iii) frequency of contractions. Increasing the load causes the tendon to undergo greater stress and hence leads to progression of the program. The load must be increased according to the patients symptoms to prevent the possibility of re- injury.[23]The speed of eccentric training should be increased with every treatment session, so that there is an increase on the load of the tendon to stimulate the mechanism of injury.[23]The third principle is frequency, usually 3 sets of 10 repetitions with elbow in full extension, forearm in pronation and with arm supported according to the patient's tolerance.[24]It is proven that eccentric exercise leads to tendon strengthening by stimulation of the mechanoreceptors in tenocytes to produce collagen which causes recovery from tendon injuries.[25]

Eccentric exercise also induces a response which normalizes a high amount of glycosoaminoglycans. Whenever eccentric exercises a given, the blood flow to the injured area stops and this causes neovascularization, which improves the blood flow and improves healing .[26]Eccentric exercise is said to lengthen the muscle –tendon complex which leads to structural remodelling of the tendon with hypertrophy and improves the tensile strength of the tendon. [27]Eccentric exercises also shows neuromuscular benefits through central adaptation of both agonist and antagonist muscles.[28]Therapeutic eccentric exercise provides structural as well as functional benefit during rehabilitation. Evidence shows that eccentric exercise can produce greater force in the muscle during dynamic movements.[29,30]

No significant difference was seen peak tendon force or length when compared with concentric exercises, yet it was found that the tendon is subjected to repeated loading and unloading in a sinusoidal-type pattern during eccentric exercises, with high-frequency oscillations in tendon force. This was not seen during concentric exercises. These findings suggest that tendon force magnitude, alone cannot be the only reason for the therapeutic benefit seen in eccentric loading. An important stimulus is provided by the pattern of tendon loading and unloading with its force fluctuations for therapeutic benefit in eccentric exercises.[31]

2. Aims and Objectives

AIM:

To study and find the impact of a device in eccentric muscle training in wrist muscles.

OBJECTIVE:

To determine the effect of a device in improving the function of the wrist extensors by eccentric exercise training.

PROCEDURE

An ethical clearance was obtained from the institutional ethical committee. Subjects were chosen according to the inclusion and exclusion criteria.

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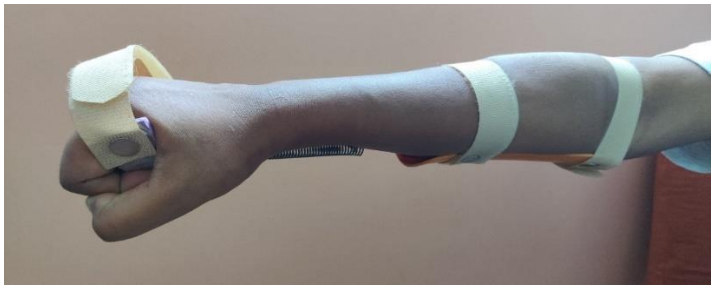
Subjects with presence of any other musculoskeletal disorder of shoulder, elbow and hand, patients with cervical radiculopathy, individuals who have undergone surgery of wrist or hand, individuals having any congenital hand deformity were excluded as these conditions can alter the study results. Male and female patients, age group of 31- 40 years, individuals who have already taken conservative treatment but have shown no significant improvement, individuals diagnosed with tennis elbow for at least 3 months or more duration were included in the study.

All patients received a written explanation of the study prior to enrollment into the study. All patients gave signed informed consent to participate in the study. A pre assessment was done one before starting the intervention. The pain was measured on a visual analogue scale where 0(cm) was "least pain imaginable and 10(cm) was "worst pain imaginable".

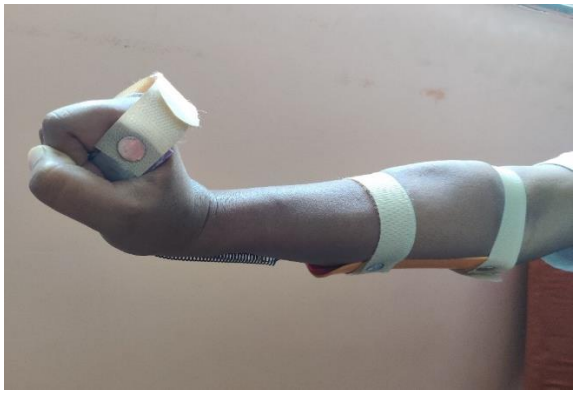
Manual muscle testing to determine the power of the wrist flexors and the wrist extensor muscles. A patient tennis elbow evaluation questionnaire which is a 15-item self-reported questionnaire to measure perceived pain and disability in people with tennis elbow.

The individuals were oriented with the work of the device and what benefit they will receive after the treatment. A standard protocol was set in which the individuals were asked to perform eccentric exercise for the wrist extensor muscle. The device was placed on the patient's hand properly and was asked to first keep the hand in neutral position then flex the wrist and then taking back to the starting position. This exercise was performed under the supervision with the dosage of 15 repetitions 3 times daily at least 4 days a week for 4 weeks. The exercise was performed in a sitting position with the elbow in full extension, wrist in pronation and the hand hanging over the edge of the chair. A home program was as also given to the patients in which the patients were asked to perform eccentric exercise once or twice daily and continue for 3 months.

After completion of the intervention post assessment was done and the data was recorded into Microsoft excel.



1.**NEUTRAL POSITION**



2.**STARTING POSITION**

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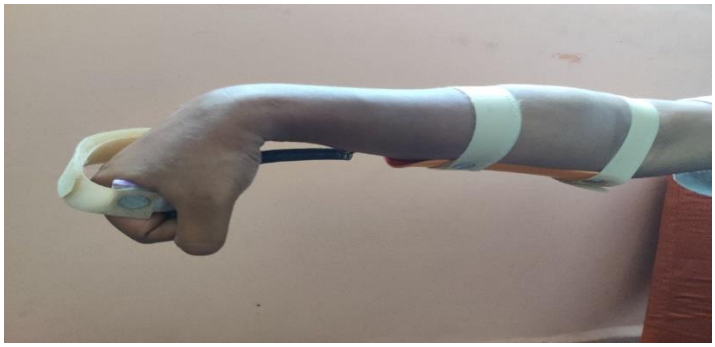

3. **ECCENTRIC CONTRACTION**

3. Results

Statistical Analysis

The statistical analysis was done using Instat app and Microsoft excel. For basic operations like Mean and SD, Microsoft excel was used where the data was initially recorded. For further calculations Instat was used. Significance for each outcome measure was calculated separately (i.e. MMT, VAS, Patient Tennis Elbow Evaluation Questionnaire). Readings of pre and post assessment were added to the app. Paired t test was used to calculate the significance.

Data presentation

Table no. 1 (MMT)- Wrist flexors

Title	Pre- assessment	Post-assessment
Mean	**3.78**	**4.94**
Median	**4**	**5**
Standard Deviation	**0.6788**	**0.2399**
Minimum	**3**	**4**
Maximum	**5**	**5**

Table no. 2 (MMT)-Wrist extensors

Title	Pre- assessment	Post-assessment
Mean	**3.420**	**4.880**
Median	**3**	**5**
Standard Deviation	**0.7848**	**0.3283**
Minimum	**2**	**4**
Maximum	**5**	**5**

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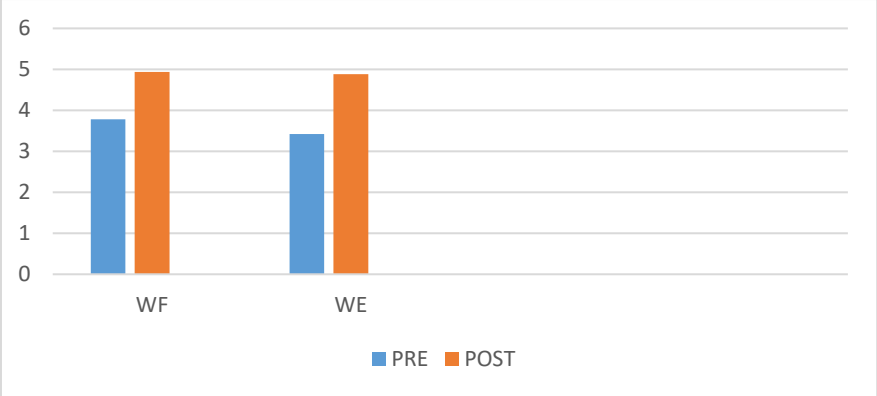

Graph No. 1 Manual Muscle Testing (MMT)

Interpretation of wrist flexors:

The two tailed P value of the paired t test is <0.0001, which is considered extremely significant. Here, t = 12.046 with 49 degrees of freedom.

Interpretation of wrist extensors: The two tailed P value of the paired t test is <0.0001, which is considered extremely significant. Here, t = 15.037 with 49 degrees of freedom.

Table no.3 (VAS at rest)

Title	Pre- assessment	Post-assessment
Mean	3.1	0.54
Median	3	0
Standard Deviation	1.644	0.6455
Minimum	0	0
Maximum	7	5

Table no .4 (VAS on activity)

Title	Pre- assessment	Post-assessment
Mean	5.88	1.7
Median	6	2
Standard Deviation	2.017	1.055
Minimum	1	0
Maximum	9	3

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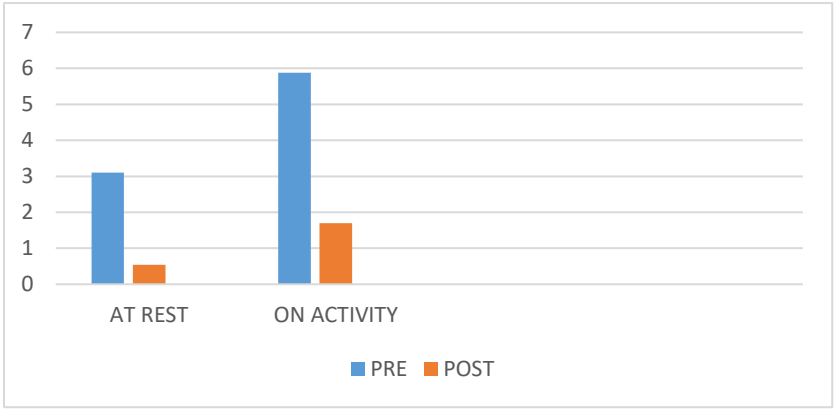


Graph No.2 Visual Analogue Scale

Interpretation of VAS at rest:

The two tailed P value of the paired t test is <0.0001, which is considered extremely significant. Here, t = 12.651 with 49 degrees of freedom

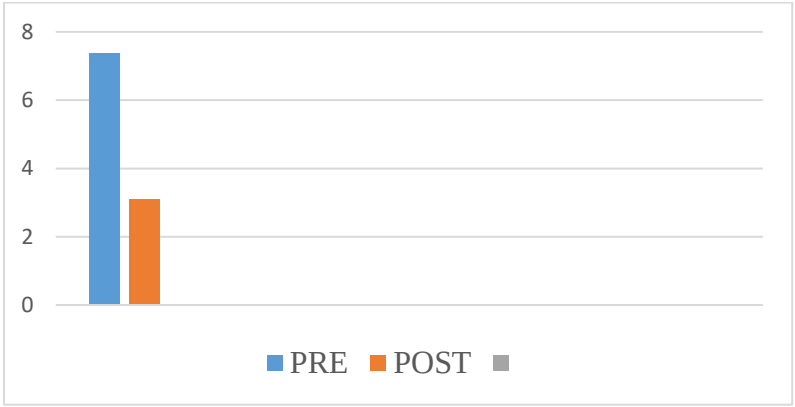
Interpretation of VAS on activity:

The two tailed P value of the paired t test is <0.0001, which is considered extremely significant.

Here, t = 20.754 with 49 degrees of freedom

Table no .5 (Patient Rated Tennis Elbow Evaluation)

Title	Pre- assessment	Post-assessment
Mean	**7.382**	**3.078**
Median	**7.6**	**3**
Standard Deviation	**1.342**	**0.8608**
Minimum	**5**	**1.6**
Maximum	**9.6**	**4.6**



Graph No.3 PRTEE

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Interpretation-

The two tailed P value of the paired t test is <0.0001, which is considered extremely significant.

Here, t = 27.353 with 49 degrees of freedom**.**

4. Discussion

Review

Tennis elbow is a common soft tissue injury usually seen in physiotherapy settings. The prevalence of tennis elbow in individuals is about 1-3%. Out of the individuals diagnosed with tennis elbow, 35% to 64% were associated with work related activities. Only 8% of individuals that play tennis are diagnosed with tennis elbow. But it is estimated that 50%of tennis players may suffer from at least one episode of tennis elbow.[3]

Tennis elbow will lead to impairment of function and is most commonly seen as pain in the elbow and lateral aspect of proximal forearm associated with forceful gripping or wrist extension.[16] Previous studies have shown that eccentric exercise when combined with adjuvant therapy showed better results with regard to reduction in pain and improvement of strength. Eccentric exercises have shown significant effect as compared to other exercises in terms of pain reduction.

There are studies in which it is clearly stated the limitation to give eccentric exercises is lack of a technique or a device which can independently give eccentric exercises. To fulfill this requirements, it was necessary to develop a device. As compared to other contractions eccentric contraction are the only ones that sufficiently generate tension that is necessary for forming fibrous tissue at the musculo-tendinous structure which in turn allows adaptation to increased tension.[1] EMG studies have shown effectiveness of eccentric training as there is lengthening of the muscle due to constant loading in the tendon.

Method

In this study a standard protocol was set in which the individuals were asked to perform eccentric exercise for the wrist extensor muscle. The device was placed on the patient's hand properly and was asked to first keep the hand in neutral position then flex the wrist and then taking back to the starting position. This exercise was performed under the supervision with the dosage of 15 repetitions 3 times daily at least 4 days a week for 4 weeks. The exercise was performed in a sitting position with the elbow in full extension, wrist in pronation and the hand hanging over the edge of the chair. A home program was as also given to the patients in which the patients were asked to perform eccentric exercise once or twice daily and continue for 3 months.

Statistics

Statistical analysis has proven that this particular study is highly significant and effective in improving strength in the wrist extensor muscles. The device has also showed improvement in power in the muscles due to the added resistance which increases load over the tendon. The patient related elbow evaluation questionnaire has also shown better results and the patient has shown improvement in performing tasks in daily life.

In this study, the pre- assessment includes VAS at rest which shows the Mean as 3.1 and the Standard Deviation as 1.644 at rest and the post- assessment results show mean as 0.54 as the Mean and 0.6455 as the Standard Deviation. The pre – assessment of VAS on activity show the Mean as 5.88 and standard deviation as 2017.The post- assessment values shows Mean as 1.7 and Standard deviation as 1.05. It concluded that interference was considered very significant with a P value of <0.0001

The pre – assessment of the wrist flexors shows Mean as 3.78 and standard deviation as 4.94 and the post – assessment showed values of Mean of 4.94 and S.D as 0.2399.This interference was considered significant with a P value of <0.0001. A scale called as PRTEE was used in which the pre- assessment value of Mean was 7.382 and that of S.D was 1.342. The post – assessment values are Mean 3.078 and the S.D of 0.8608. This interference was considered very significant with a P value of <0.0001.

Based on the statistical results, it has been concluded that the device has not only reduced pain but also improved strength and improved the functional ability of the individuals. The device works on the principle of eccentric training which focuses on eccentric contraction of the muscles mainly the wrist extensors. Post assessment results have shown that pain has been reduced when compared with the pre intervention as

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eccentric exercise causes neovascularization and promotes healing.

5. Conclusion

On the basis of the results of the study, it can be concluded that the device used for eccentric training in the condition of tennis elbow is very effective in reducing pain, improving the strength in the involved muscles. The study also concluded that the device has improved the Patients ability to perform activities of daily living.

References

[1] Yoon SY, Kim YW, Shin IS, Kang S, Moon HI, Lee SC. The beneficial effects of eccentric exercise in the management of lateral elbow tendinopathy: A systematic review and meta-analysis. Journal of clinical medicine. 2021 Jan;10(17):3968.

[2] Bisset LM, Vicenzino B. Physiotherapy management of lateral epicondylalgia. Journal of physiotherapy. 2015 Oct 1;61(4):174-81.

[3] Garden RS. Tennis elbow. The Journal of Bone and Joint Surgery. British volume. 1961 Feb;43(1):100-

[4] 6

[5] Wadsworth TG. Tennis elbow: conservative, surgical, and manipulative treatment. British medical Journal (Clinical research ed.). 1987 Mar 7;294(6572):621.

[6] McVay CB: Surgical Anatomy, Vol. 2, (6th Ed), Philadelphia: W.B. Saunders Company, 1984

[7] Bryan RS, Morrey BF. The elbow and its disorders. Morrey BF ed. Fractures of the distal humerus. Philadelphia, WB Saunders: 325. 1985;333.

[8] Carp L: Tennis elbow caused by radio- humeral bursitis. Arch Surg 24:905- 922, 1932

[9] Osgood RB: Radiohumeral bursitis, ep- icondylitis, epicondylalgia. Arch Surg 4:420-433, 197

[10] Nirschl RP: Prevention and treatment of elbow and shoulder injuries in the tennis player. Clin Sports Med 7:289- 308, 198

[11] Cieck /H, Saliba E: Application of mo- dalities in overuse syndromes. Clin Sports Med 6:427-466, 1987

[12] LaFreniere I: Tennis elbow evaluation, treatment and prevention. Phys Ther 59:742-746, 197

[13] Nirschl RP: Tennis elbow. Orthop Clin North Am 4:787-799, 1973

[14] Wright A, Vicenzino B. Lateral epicondylalgia II: therapeutic management. Physical Therapy Reviews. 1997 Mar 1;2(1):39-48.

[15] Pienimaki T. Conservative treatment and rehabilitation of tennis elbow: a review article. Critical Reviews™ in Physical and Rehabilitation Medicine. 2000;12(3).

[16] Bernhang AM, AM B. The many causes of tennis elbow.

[17] Noteboom T, Cruver R, Keller J, Kellogg B, Nitz AJ. Tennis elbow: a review. Journal of Orthopaedic & Sports Physical Therapy. 1994 Jun;19(6):357-66.

[18] Sevier TL, Wilson JK. Methods utilized in treating lateral epicondylitis. Physical therapy reviews. 2000 Jun 1;5(2):117-24.

[19] Khan KM, Cook JL, Kannus P, Maffulli N, Bonar SF. Time to abandon the "tendinitis" myth: painful, overuse tendon conditions have a non-inflammatory pathology. Bmj. 2002 Mar 16;324(7338):626-7.

[20] Selvier T, Wilson J. Treating lateral epicondylitis. Sports Med 1999;28:375–80.

[21] Stanish WD, Rubinovich RM, Curwin S. Eccentric exercise in chronic tendinitis. Clinical orthopaedics and related research. 1986 Jul 1(208):65-8.

[22] Stanton P, Purdam C. Hamstring injuries in sprinting—the role of eccentric exercise. Journal of Orthopaedic & Sports Physical Therapy. 1989 Mar;10(9):343-9.

[23] Fyfe IA, Stanish WD. The use of eccentric training and stretching in the treatment and prevention of tendon injuries. Clinics in sports medicine. 1992 Jul 1;11(3):601-24.

[24] Kraushaar B, Nirschl R. Current concepts review – tendinosis of the elbow (tennis elbow). Clinical features and findings of histologica.

[25] Hawary R, Stanish W, Curwin S. Rehabilitation of tendon injuries in sport. Sports Med 1997;24:347–58.

[26] Öhberg L, Lorentzon R, Alfredson H. Eccentric training in patients with chronic Achilles tendinosis: normalised tendon structure and decreased thickness at follow up. British journal of sports medicine. 2004 Feb 1;38(1):8-11.

[27] Ohberg L, Lorentzon R, Alfredson H. Neovascularisation in Achilles tendons with

ISSN: 2309-5288 (Print)
ISSN: 2309-6152 (Online)
CODEN: JCLMC4
Journal of Coastal Life Medicine

painful tendinosis but not in normal tendons: an ultrasonographic investigation. Knee Surgery Sports Traumatol Arthrosc 2001;9:233–8

[28] Cyriax JH. The pathology and treatment of tennis elbow. JBJS. 1936 Oct 1;18(4):921-40.

[29] Pensini M, Martin A, Maffiuletti NA. Central versus peripheral adaptations following eccentric resistance training. International journal of sports medicine. 2002 Nov;23(08):567-74.

[30] Fukashiro S, Komi PV, Jarvinen M, et al. In vivo Achilles tendon loading during jumping in humans. Eur. J. Appl. Physiol. Occup. Physiol. 1995; 5: 453–8

[31] Komi PV, Buskirk ER. Effect of eccentric and concentric muscle conditioning on tension and electrical activity of human muscle. Ergonomics. 1972; 15: 417–34.

[32] Rees JD, Lichtwark GA, Wolman RL, Wilson AM. The mechanism for efficacy of eccentric loading in Achilles tendon injury; an in vivo study in humans. Rheumatology. 2008; 47: 1493–7

[33] Allander E. Prevalence, incidence, and remission rates of some common rheumatic diseases or syndromes. Scandinavian journal of rheumatology. 1974 Jan 1;3(3):145-53.

[34] Rompe JD, Overend TJ, MacDermid JC. Validation of the patient-rated tennis elbow evaluation questionnaire. Journal of Hand Therapy. 2007 Jan 1;20(1):3-11.

[35] Potter HG, Hannafin JA, Morwessel RM, DiCarlo EF, O'Brien SJ, Altchek DW. Lateral epicondylitis: correlation of MR imaging, surgical, and histopathologic findings. Radiology. 1995 Jul;196(1):43-6.

[36] Ollivierre CO, Nirschl RP, Pettrone FA. Resection and repair for medial tennis elbow: a prospective analysis. The American Journal of Sports Medicine. 1995 Mar;23(2):214-21.

[37] COONRAD RW, HOOPER WR. Tennis elbow: its course, natural history, conservative and surgical management. JBJS. 1973 Sep 1;55(6):1177-82.

[38] FROIMSON AI. Treatment of tennis elbow with forearm support band. JBJS. 1971 Jan 1;53(1):183-4.

[39] Sarkar K, Uhthoff HK. Ultrastructure of the common extensor tendon in tennis elbow. Virchows Archiv A. 1980 Apr;386(3):317-30.

[40] BOYD HB, MCLEOD JR AC. Tennis elbow. JBJS. 1973 Sep 1;55(6):1183-7.

[41] Unverferth LJ, Olix ML. The effect of local steroid injections on tendon. The Journal of sports medicine. 1973 Jul;1(4):31-7.