Physiotherapy Treatment of Tennis Elbow: A Review

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Abstract- *Tennis elbow is a chronic condition that can be challenging to treat. Physiotherapy is often a treatment of choice, but previous reviews have failed to draw any conclusions as to which is the most effective therapeutic modality in the management of this condition.*

Key messages of this review best available evidence are for active exercise approaches, possibly supplemented by manual therapy and taping treatments. There is insufficient evidence to recommend the use of passive modalities such as electrotherapy or acupuncture at present. Physiotherapy is a cost-effective form of treatment

I. INTRODUCTION

Tennis elbow is one of the most commonlyupper limb conditions [1]. Its incidence in general practice is 4 –8 per 1100 per year [2], with as many as 18% of workers in highly repetitive jobs reporting the condition [3 –5]. Its incidence peaks in the 35 –50-year-old age group [6].

Tennis elbow is seen in non- tennis players [7]: however, elbow pain is encountered in up to 50% of tennis players, with 75 –90% of these cases being attributable to tennis elbow [8, 9].

The disorder is characterized by pain over the lateral aspect of the elbowassociated with resisted wrist and finger extension and gripping activities.

This condition substantially on society and health care systems, with between 20 and 40% of individuals with tennis elbow, taking a leave of absence of an average duration of 14 weeks [2].It also has a huge economic impact in terms of workers' compensation claims and even early retirement [10]. However, longitudinal studies have shown that a large proportion of patients improve over time with spontaneous recovery seen in 70 –90% of patients within 2 years [11 –13].

The aetiology of tennis elbow is poorly understood. Kraushaar & Nirschl's [14] microscopic study demonstrated the presence of fibroblastic tissue and vascular invasion of the common extensor tendon, described as angiofibroblastic tendonosis, implying a degenerative tendinopathy. However, recent studies have demonstrated the presence of the neuropeptides, substance P and calcitonin related gene peptide (CRGP) in sensory nerve fibres supplying the extensor carpi radialis brevis (ECRB) [15, 16].

This lack of understanding regarding its aetiology has led to a large number of treatments, including physiotherapy, being advocated. As up to 40% of all patients seen in primary care with tennis elbow are referred to physiotherapy [2], the aim of this review is to examine the evidence of effectiveness of frequently used physiotherapy management of tennis elbow. For the purpose of this review, that modalities were classified as electrotherapeutic or physical interventions.

II. SEARCH STRATEGY

Computerized searches were performed using Medline, Embase, and the Physiotherapy Evidence Database. Randomized controlled trials were reviewed using the terms tennis elbow, lateral elbow pain, lateral epicondylagia and physiotherapy, either individually or in various combinations. Other references identified from existing reviews or from papers cited in previous publications were also reviewed.

ELECTROTHERAPY INTERVENTIONS

Modalities reviewed include ultrasound, laser therapy or electromagnetic field therapy, Heat therapy. For the purpose of this review extracorporeal shock wave therapy (ESWT) was not included as it is not commonly utilized by Indian physiotherapists. Laser therapyThis is used infrequently by physiotherapists in India, in the management of tennis elbow [6]. In the short term the efficacy of this treatment modality is questionable as is demonstrated by the differing results seen in previous studies. There is, at present, no evidence of long-term effect using laser when compared with placebo treatment [18 –22].

Pulsed short wave diathermy

This was used by just under 20% of physiotherapists in Greenfield & Webster's study [6], despite there being no conclusive evidence regarding its effectiveness in the management of tennis elbow. Only one small study examined its effectiveness vs a placebo, concluding there were no differences between groups at final review, following 10 weeks of treatment [23].

Ultrasound

Pulsed and continuous ultrasound is used by just under half of physiotherapists treating tennis elbow [6],the overall efficacy of the treatment for musculoskeletal disorders is in debate. Varying effects are seen in trials comparing pulsed ultrasound with placebo [24, 25], using a range of outcome measures. When compared with other modalities, such as injections or transcutaneous electrical nerve stimulation [26, 27], there were no significant differences in outcomes between groups, with weak evidence for its effectiveness. One of the studies which is ultrasound used with a steroid coupling gel was used. Following nine sessions of treatment, there were no additional benefits in using a steroid coupling gel, compared with using ultrasound alone.

PHYSICAL INTERVENTIONS

Treatments reviewed include acupuncture, ice therapy, the use of orthotic devices, manual therapy, massage, and manual exercise therapy.

Acupuncture

Acupuncture is frequently used by physiotherapists in the management of tennis elbow [6]. very few acupuncture studies to date have failed to prove conclusively that the short-term relief in pain seen gives rise to long term functional improvement [29 –32]. No trials to date have assessed, concentrated or commented on the potential adverse effects of this particular form of treatment. [33] concludes there is insufficient evidence to support or refute the use of acupuncture. Further trials utilizing appropriate methodology and adequate sample sizes are needed before firm conclusions can be drawn regarding this treatment modality.

Ice

One study was identified that investigated the effect of ice therapy on tennis elbow. Manias & Stasinopoulos's parallel group study [34]Compared an exercise and ice group with exercise alone, with the ice being applied for 15 minutes after each exercise session. At 4 months follow-up no significant differences were seen between the two groups, indicating that ice may be ineffective as a treatment in the management of tennis elbow.

Manual therapy and massage

Abbot, Patla & Jensen's small study [35] demonstrated a favourable initial response to a manual therapy technique, a mobilization with movement (MWM), in terms of pain free grip strength and maximum grip strength. However, these results were only generalizable to a single treatment session and not an episode of care. Vicenzino & Wright [36] utilized a single subject design and found four treatment sessions of MWM, a home programme inclouding MWM, and taping to replicate MWM improved all measures of pain and function. This included pain free grip strength at the end of 6 weeks post-treatment assessment phase, but as follow-up time was short, recurrence rates following this regime are unknown. Kochar & Dogra's small study [37] compared a 3-week trial of ultrasound and MWM compared with ultrasound alone. Both groups then underwent a10-week programme of progressive upper limb rehabilitation, including the use of weights. Findings were a significant improvement in the MWM group in terms of pain and the weight test, but no difference in grip strength. The MWM group also had a faster recovery time compared with the ultrasound group. Again though, follow-up time was short. These studies echo the results seen in previous studies with only immediate or short-term effects seen, after the application of manual therapy techniques at the elbow and cervical spine [38], with only Struijset al. [39] reporting outcomes at the end of a 6-week programme. However, there does appear to be some evidence in favour of positive initial effects of mobilization, including MWM, which warrants further investigation.

Deep transverse frictional

massage, which was initially advocated by Cyriax[40]. Verhar et al.'s [41] randomized controlled trial compared a corticosteroid injection with 12 sessions of transverse frictions over a 4-week treatment period. At 6 weeks subjective and objective markers were better in the steroid group, but no differences were found between groups at 12 months follow-up. The authors concluded that friction massage was no better than an injection in the management of tennis elbow. Despite the limited evidence to endorse or refute the effects of frictional massage, it was used as a form of treatment always or frequently by over two thirds of respondents in Greenfield & Webster's [6] study.

Orthotic devices and taping

Braces or epicondylar clasps are prescribed in up to 25% of cases of tennis elbow [42, 43] Biomechanical studies have shown that forearm bracing has a direct effect on reducing stresses on the origin of ERCB, but clinical studies are more equivocal. Struijs et al. [44] have proposed the use of a new clinical test, the extensor grip test, where a clinician manually replicates the effect of a brace, as a predictive factor for the effectiveness of bracing, as a treatment for tennis elbow in the short term.

Jensen et al. [45] compared the use of an off the shelf orthotic with a corticosteroid injection over a 6-week period. Both groups showed significant improvements from baseline measurements, but no differences were found between groups. However, given that bracing would appear to have the lesser risk of side effects, Jensen et al. advocated its use. Wuori [46]compared an off the shelf orthotic with two different types of placebo brace, as well as a control group, and found no significant differences between the brace and the placebo device on any ofthe outcome measures used. Faes et al. [47] in a randomized controlled trial compared a new dynamic extensor brace worn for 3 months, with a control group. This study found a significant improvement in pain reduction and pain free grip strength in the bracing group, which was maintained at 6 months follow-up. The most recent Cochrane review [48] concluded that with respect to bracing, there were only a limited number of trials, using too few outcome measures, with limited long-term results. Therefore, no definite conclusions could be drawn concerning the effectiveness of orthotic devices. In conclusion, more well designed and well conducted randomized controlled trials are warranted.

Struijs et al. [49], in a large randomized controlled trial, examined the cost effectiveness of a brace compared with a physiotherapy regime comprising of ultrasound, friction massage and exercises. At 12 months follow-up there was little difference clinically between groups, but physiotherapy was found to be the most cost-effective treatment. Direct health care costs were higher in the physiotherapy group, but indirect costs such as work absence were substantially higher in the brace group. This study may suggest that the direct cost of physiotherapy is worthwhile, as cost is often a decisive factor in current medical practice, as to whether an intervention is implemented.

Many therapists use taping as an adjunct to exercise, in order to relieve pain and allow functional restoration of movement patterns. Vicenzino et al's [50] small study demonstrated that taping may be useful as an adjunct to exercise. When comparing specific diamond taping over the elbow, compared with placebo taping and a control group, diamond taping had a positive effect of the order of 10% on pain free grip strength and pain pressure threshold, which was maintained for up to 30 minutes after the removal of the tape. However, further research is required before firm conclusions regarding the effectiveness of taping can be drawn.

Exercise programmes

Exercise is one of the most commonly used treatments in tennis elbow management by physiotherapists, especially progressive stretching exercises [6].

In a small study Pienimaki et al. [52] compared a 6 –8-week trial of exercises including stretches, with ultrasound. This showed a favourable effect on pain but not maximal grip strength, with the authors concluding that progressive exercise therapy was more effective than ultrasound. In a 3 year follow up study [53] of the same group of patients, the exercise group had significantly less pain and significantly less co-interventions, such as physiotherapy or medical consultations. The exercise group also reported less sickness absence days due to their elbow condition.

Bisset et al. [12] in a sufficiently powered, well-executed trial, compared eight sessions of community-based physiotherapy, with a steroid injection or a wait and see approach. The initial results were more favourable in the injection group, but this group had a higher recurrence rate and significantly poorer outcomes at 12 months follow-up in comparison with the physiotherapy group. There were no significant differences between the physiotherapy and the wait and see group, but less co-interventions were sought by the physiotherapy group, echoing the results of previous studies. The physiotherapy group also experienced quicker pain relief than the wait and see group. The authors questioned whether it was it worth the time and cost associated with physiotherapy to gain faster relief and perhaps avoid other treatment, in the knowledge that over the course of the next few months, the outcomes were probably similar. They also queried the use of corticosteroid injections in the use of chronic tennis elbow, with the conclusion being to demedicalize this condition, allow the elbow to recover and consider referral for physiotherapy. This study confirms the finding of a previous study, which found physiotherapy in a primary care randomized controlled trial, gave no added benefit over a wait and see approach [13]. The conclusion drawn from this study was that given appropriate advice, tennis elbow is a self-limiting condition, in most cases. It should be noted, however, that the physiotherapy regime used in the above study consisted of friction massage, ultrasound and exercise, which may not reflect the approach taken by many physiotherapists today.

Eccentric training programmes with patients with tennis elbow. Eccentric strength training programmes are a key element of rehabilitation [54 –56], with literature supporting their use in other chronic tendinopathies[57 –59], as well as tennis elbow.

Eccentric exercise

It is claimed that eccentric training results in tendon strengthening stimulating mechanoreceptors in tenocytes to produce collagen, which is probably the key cellular mechanism that determines recovery from tendon injury [60 – 62].In addition, eccentric training may induce a response that normalizes the high concentrations of glycosaminogly cans. It may also improve alignment of collagen within the tendon and stimulate collagen cross linkage formation, both of which improve the tensile strength of tendons and tendon remodelling [60 –65], which is supported by animal studies [66]. However, as the basic pathophysiology of tendinopathy is poorly understood, the mechanisms by which eccentric exercise may help resolve tendinopathy is also poorly understood [67].

Martinez-Silvestrini et al.'s [68] study compared eccentric exercise plus stretches, concentric exercise plus stretches and a stretching alone group. There were no significant differences in outcome between groups; however, the programme of exercise undertaken was of short duration, with only a short-term follow- up. Other studies involving longer exercise programmes have shown more favourable results. Svenlov & Adolfsons [69] small randomized controlled trial of 3 months of eccentric exercise compared with daily stretches, found that the eccentric training programme produced significant improvements in grip strength, with complete resolution of symptoms in 86% of this group. A more recent study comparing isokinetic eccentric work with a standard rehabilitation programme, demonstrated a reduction in pain and an absence of grip deficit in individuals, following the eccentric programme. The study also showed normalization of ultrasound findings in 48% of the eccentric group compared with 28% in the other treatment group [70]. However, this study used specialized equipment for the isokinetic group, which is not freely available to most patients. Finestone & Rabinovitch [71] suggested that a free weight programme may produce equally beneficial results, but there are no data available to support this.

In conclusion, there is some evidence to support the use of eccentric training programmes in tennis elbow, but further investigation is warranted with more rigorous methodological design. The most common failings in the studies above were short follow-up time, inadequate therapist, assessor and subject blinding, lack of intention to treat analysis and the use of poor outcome measures. Very few studies failed to use pain free grip strength as a primary outcome measure, although its use has been recommended in the literature.

Outcome measures

Grip dynamometry is an established outcome measure used in tennis elbow research studies, as it has shown to have excellent inter-observer reliability [72]. Greenfield & Webster's [6] study of physiotherapy practice showed that testing grip strength with a dynamometer was undertaken by over 60% of physiotherapists, but there was little consensus on testing position. However, standardized testing positions need to be undertaken, as previous studies have shown significant differences in grip strength with different position[73,74]. Also,most physiotherapists recorded maximal grip strength, although this has been shown to be less valid than pain free grip strength. Stratford et al. showed maximal grip strength demonstrated a greater responsiveness to change during a single intervention, but it had poor validity as a measurement of clinically important change over time [75]. Pain free grip strength has been shown to be more sensitive in measuring change over time, with a strong correlation between levels of disability and deficits in pain free grip strength. This responsiveness to change coupled with its high reliability, has promoted its use as an outcome measure in both the research and clinical setting.

III. DISCUSSION

There is a paucity of evidence for physiotherapy in the management of chronic tennis elbow especially that of long-term effect, which may be due to methodological differences in the research reported to date. Two previous reviews concluded more research was needed to investigate the effectiveness of physiotherapy in the management of tennis elbow [76, 77]. Also, many previous studies have been undertaken in the secondary care setting. Future research should also address the fact that results from hospital-based studies are not generalizable to the primary care setting. Patients recruited is Secondary care represent an unknown group of individuals who probably have more severe, persistent complaints. Also, many systematic reviews concerning physiotherapy have failed to address the issue of adequate treatment procedures and the optimal doses of treatment needed to produce significant treatment effects [78 – 81]. It is no longer valid to include trials in systematic reviews with non-optimal treatment doses. This is in order to ensure adequate methodology under equal terms to balance evidence of effects for both physical and medical interventions.

The best available evidence to date would appear to support the use of exercise, supplemented by manual therapy techniques and taping. However, the tape and manual therapy studies only show evidence of a moderate to large initial effect, with lack of long-term follow-up data. Therefore, these preliminary findings would appear to warrant further investigation. Currently, there is insufficient evidence to recommend the use of passive modalities such as Electrotherapy and acupuncture in the management of tennis elbow. Treatment should be directed to improve the limited function of the upper limb, and not merely be aimed at symptomatic relief.

REFERENCES

[1] Thurston AJ. Conservative and surgical treatment of tennis elbow: a study of outcome. Aust N Z J Surg 1999; 68(8):568 –72.
[2] Assendfelt WJ, Hay EM, Adshead R, Bouter LM. Corticosteroid injections for lateral epicondylitis: a systematic overview. Br J Gen Pract 1996; 46:209 –16.
[3] Chiang HC, Ko YC, Chen SS, et al. Prevalence of shoulder and upper limb disorders among workers in the fish processing industry. Scand J Work Environ Health 1993; 19:126 –31.
[4] Kurppa K, Viikari Juntura E, Kuosma E, Huuskonen M, Kivi P. Incidence of tenosynovitis or peritendonitis and epicondylitis in a meat processing factory. Scand J Work Environ Health 1991; 17:32 –7.
[5] Ranney D, Wells R, Moore A. Upper limb musculoskeletal disorders in highly repetitive industries: precise anatomical physical findings. Ergonomics 1995; 38:1408 –23.
[6] Greenfield C, Webster V. Chronic lateral epicondylitis; survey of current practice in outpatient departments in Scotland. Physiotherapy 2002; 88(10):578 –94.
[7] Nirschl RP, Pettrone FA. Tennis elbow: the surgical treatment of lateral epicondylitis. J Bone Joint Surg 1979; 61-A:832 –9.
[8] Gruchow H, Pelletier D. An epidemiologic study of tennis elbow. Incidence, recurrence, and effectiveness of prevention strategies. Am J Sports Med 1979; 7:234 –8.
[9] Nirschl R. Tennis elbow. Orthop Clin North Am 1973; 4:787 –800.
[10] Dimberg L. The prevalence and causation of tennis elbow in a population of workers in an engineering industry. Ergonomics 1987; 30:573 –80.
[11] Coonrad RW, Hooper R. Tennis elbow; its course, natural history, conservative and surgical management. J Bone Joint Surg 1973; 55-A:1177 –87.
[12] Bisset L, Beller E, Jul G, Brooks P, Darnell R, Vicenzino B. Mobilisation with movement and exercise, corticosteroid injection, or wait and see for tennis elbow: randomised trial. Br Med J 2006; 333:939 –945.
[13] Smidt N, Van der Windt D, Assendfelt W, et al. Corticosteroid injections, physiotherapy, or a wait-and-see policy for lateral epicondylitis: a randomised controlled trial. Lancet 2002; 359:657 –62.
[14] 14. Kraushaar BS, Nirschl RP. Tendonosis of the elbow. Clinical features and findings of histological, immunohistochemical and electron microscopy studies. J Bone Joint Surg 1999; 81-A:259 –78.1. Ljung BO, Forsgren S, Friden J. Substance P and calcitonin gene-related peptide expression at the extensor carpi radialis brevis muscle origin: implications for the aetiology of tennis elbow. J Orthop Res 1999; 17:554 –9.
[15] Fedorczyk JM. Tennis elbow: blending basic science with clinical practice. J Hand Ther 2006; 19:146 –53.
[16] Zeisig E, Ohberg L, Alfredson H. Extensor origin vascularity related to pain in patients with tennis elbow. Knee Surg Sports Traumatol Arthrosc 2006; 14:659 –63.
[17] Basford J, Sheffield C, Cieslak K. Laser therapy: a randomised, controlled trial of the effects of low intensity laser irradation on lateral epicondylitis. Arch Phys Med Rehabil 2000; 81:1504 –10.
[18] Haker E, Lundeberg T. Is low-energy laser treatment effective in lateral epicondylagia? J Pain Symptom Manage 1991; 6:241 –6.
[19] Haker E, Lundeberg T. Lateral epicondylagia: report of non-effective midlaser treatment. Arch Phys Med Rehabil 1991; 72:984 –8.
[20] Lundeberg T, Haker E, Thomas M. Effect of laser versus placebo in tennis elbow. Scand J Rehabil Med 1987; 19:135 –8.
[21] Vasseljen O, Hoeg N, Kjeldstad B, et al. Low level laser versus placebo in the treatment of tennis elbow. Scand J Rehabil Med 1992; 24:37 –42.
[22] Devereaux M, Hazelman B, Thomas P. Chronic humeral epicondylitis: a double-blind controlled assessment of pulsed electromagnetic field therapy. Clin Exp Rheumatol 1985; 3:333 –6.
[23] Haker E, Lundeberg T. Pulsed ultrasound treatment in lateral epicodylagia. Scand J Rehabil Med 1991; 23:115 –8.
[24] Lundeberg T, Abrahamsson P, Haker E. A comparative study of continuous ultrasound, pulsed ultrasound and rest in epicondylagia. Scand J Rehabil Med 1988; 20:99 –101.
[25] Binder AI, Hazelman BL. Lateral humeral epicondylitis: a study of natural history and the effect of conservative therapy. Br J Rheumatol 1983; 22:73 –76.
[26] Halle JS, Franklin RJ, Karalfa BL. Comparison of four treatment approaches for lateral epicondylitis of the elbow. J Orthop Sports Ther 1986; 8:62 –9.
[27] Stratford P, Levy D, Gauldie S, et al. The evaluation of phonophoresis andfrictionmassageastreatmentsforextensorcarpiradialistendinitis: a randomized controlled trial. Physiother Can 1989; 41:93 –9.
[28] Davidson J, Vandervoot A, Lessard L, et al. The effect of acupuncture versus ultrasound on pain level, grip strength

and disability in individuals with lateral epicondylitis: a pilot study. Physiother Can 2001; 53:195 –202.

[29] Fink M, Wolkenstein E, Karst M, et al. Acupuncture in chronic epicondylitis: a randomised controlled trial. Rheumatology 2002; 41:205 –9.

[30] Fink M, Wolkenstein E, Luennemann M, et al. Chronic epicondylitis: effects of real and sham acupuncture treatment: a randomised con- trolled patient and examiner blinded long-term trial. Rheumatology 2002; 9:210 –5.

[31] Molsberger A, Hille E. The analgesic effect of acupuncture in chronic tennis elbow pain. Br J Rheumatol 1994; 33:1162 –5.

[32] Green S, Buchbinder R, Barnsley L, et al. Acupuncture for lateral elbow pain. Cochrane Database Syst Rev 2002.

[33] Manias P, Stasinopoulos D. A controlled pilot trial to study the effectiveness of ice as a supplement to an exercise programme for the management of lateral elbow tendinopathy. Br J Sports Med 2006; 40:81 –5.

[34] Abbott JH, Patla CE, Jensen RH. The initial effects of an elbow mobilisation with movement technique on grip strength in subjects with lateral epiconylagia. Man Ther 2001; 6:163 –9.

[35] Vincenzino B, Wright A. Effects of anovel manipulative physiotherapy technique on tennis elbow: a single case study. Man Ther 1995; 1:30 –5.

[36] Kochar M, Dogra A. Effectiveness of a specific physiotherapy regimen on patients with tennis elbow. Physiotherapy 2002; 88:333 –411. Vincenzino B, Collins D, Wright A. The initial effects ofacervicalspine manipulative physiotherapy treatment on the pain and dysfunction of lateral epicondylagia. Pain 1996; 68:69 –74.

[37] Struijs P, Damen P, Bakker E, et al. Manipulation of the wrist for management of of lateral epicondlylitis: a randomised pilot study. Phys Ther 2003; 83:608 –16.

[38] Cyriax HJ, Cyriax JP. Cyriax's illustrated manual of orthopaedic medicine. Oxford: Butterworth-Heinemann, 1988.

[39] Verhaar JA, Walenkamp GH, van Mameren H, Kester AD, van der Linden AJ. Local corticosteroid injection versus Cyriax-type physiotherapy for tennis elbow. J Bone Joint Surg Br 1996; 78:128 –32.

[40] Ernst E. Conservative therapy for tennis elbow. Br J Clin Pract 1992; 46:55 –7.

[41] Keus SHJ, Smidt N, Assendfelt WJJ. Treatmentoflateralepicondylitis in general practice: results of a survey. Eur J Gen Pract 2002; 8:71 –2.

[42] Struijs PAA, Assendfelt WJJ, Kerkhoffs GMM, Souer S, van Diyk CN. The predictive value of the extensor grip test for the effectiveness of bracing for tennis elbow. Am J Sports Med 2005; 33:1905 –9.

[43] Jensen B, Bliddal H, Danneskiold-Samsoe B. Comparison of two different treatments of lateral humeral epicondylitis. A randomised controlled trial. Ugeskr Laeger 2001; 163:1427 –31.

[44] Wuori J, Overend T, Kramer J, et al. Strength and pain measures assosciated with lateral epicondylitis bracing. Arch Phys Med Rehabil 1998; 79:832 –7.

[45] Faes M, van der Akker B, de Lint JA, Kooloos JG, Hopman MTE. Dynamic extensor brace for lateral epicondylitis. Clin Orthop Relat Res 2006; 442:149 –57.

[46] Struijs PAA, Smidt N, Arola H, et al. Orthotic devices for tennis elbow.

[47] Cochrane Database Syst Rev 2001.

[48] Struijs PAA, Korthalss -de Bos IBC, van Tulder MW, et al. Cost effectiveness of brace, physiotherapisy, or both for treatment of tennis elbow. Br J Sports Med 2006; 40:637 –43.

[49] Vicenzino B, Brooksbank J, Minto J, et al. Initial effects of elbow taping on pain-free grip strength and pressure pain threshold. JOrthop Sports Phys Ther 2003; 33:400 –7.

[50] Hannafin JA, Schelkun PH. How I manage tennis and golfers elbow.Physician Sportsmed 1996; 20:63 –8.

[51] 52. Pienimaki T, Tarvainen T, Siira P, et al. Progressive strengthening and stretching exercises and ultrasound for chronic lateral epicondylitis. Physiotherapy 1996; 82:522 –30.

[52] Pienimaki T, Karinen P, Kemila T, Koivukangas P, Vanharanta H. Long-term follow-up of conservatively treated chronic tennis elbow patients. A prospective and retrospective analysis. Scand JRehabil Med 1998; 30:159 –66.

[53] Ashe MC, McCauley T, Khan M. Tendonopathies in the upper extremity: a paradigm shift. J Hand Ther 2004; 17:329 –34.

[54] 55. Wang JH, Iosifidis MI, Fu FH. Biomechanical basis for tendonopathy.Clin Orthop Relat Res 2006; 443:320 –32.

[55] Whaley AL, Baker CL. Lateral epicondylitis. Clin Sports Med 2004; 23:677 –91.

[56] Alfredson H, Pietila T, Jonsson P, et al. Heavy-load eccentric calf muscle training for the treatment of chronic achilies tendonosis. Am J Sports Med 1998; 26:360 –6.

[57] Fahlstrom M, Jonsson P, Lorentzon R, et al. Chronic Achilles tendon pain treated with eccentric calf-muscle training. Knee Surg Sports Traumatol Arthrosc 2003; 11:327 –33.

[58] Mafi N, Lorentzon R, Alfredson H. Superior short-term results with eccentric calf muscle training compared to concentric training in a randomised prospective multicentre study on patients with chronic Achilles

tendonosis. Knee Surg Sports Tramatol Arthrosc 2001; 9:42 –7.

[59] Khan K, Cook J, Taunton J, et al. Overuse tendonosis, not tendonitis: a new paradigm for adifficult clinical problem. Physician Sportsmed 2000; 28:38 –48.

[60] Khan KM, Cook JL, Kannus P, et al. Time to abondon the word tendonitis myth. Br Med J 2002; 324:626 –7.

[61] Ohberg L, Lorentzen R, Alfredson H. Eccentric training in patients with Achilies tendinosis: normalised tendon structure and decreased thickness at follow-up. Br J Sports Med 2004; 38:8 –11.

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

[63] Jeffery R, Cronin J, Bressel E. Eccentric training: Clinical applications to Achilles tendinopathy. NZJ Sports Med 2005; 33:22 –30.

[64] Peers KHE, Lysens RJJ. Patellar tendinopathy in athletes: current diagnostic and therapeutic recommendations. Sports Med 2005; 35:71 –87.

[65] Vilarta R, Vidal BDC. Ansiotropic and biomechanical properties of tendons modified by exercise and denervation: aggregation and macromolecular order in collagen bundles. Matrix 1989; 9:55 –61.

[66] Woodley B, Newsham-West RJ, Baxter GD. Chronic tendinopathy: effectiveness of eccentric exercise. Br J Sports Med 2007; 41:188 –98.

[67] Martinez-Silvestrini JA, Newcomer KL, Gay RE, et al. Chronic lat- eral epicondylitis; Comparative effectiveness of a home exercise programme including stretching alone versus stretching supple- mented with eccentric or concentric strengthening. J Hand Ther 2005; 18:411 –20.

[68] Svenlov B, Adolfsson L. Non-operative treatment regime including eccentric training for lateral humeral epicondylagia. Scand J Med Sci Sport 2001; 11:328 –34.

[69] Croisier JL, Foidart-Dessall M, Tinant F, Crieland JM, Forthomme B. An isokinetic eccentric programme for the management of chronic lateral epicondylar tendinopathy. Br J Sports Med 2007; 41:269 –75.71. Finestone HM, Rabinovitch, DL. Tennis elbow no more. Can Fam Physician 2008; 54:1115 –6.

[70] Smidt N, van der Windt DA, Assendfelt WJ, et al. Interobserver reproducibility of the assessment of severity of complaints, grip strength and pressure pain threshold in patients with lateral epicondylitis. Arch Phys Med Rehabil 2002; 83:1145 –50.

[71] De Smet L, Fabry G. Grip force reduction in patients with tennis elbow: Influence of elbow position. J Hand Ther 1997; 10:229 –31.

[72] Ng GYF, Fan ACC. Does elbow position affect strength and reproducibility of power grip measurements. Physiotherapy 2001; 87:68 –72.

[73] Stratford P, Levy D, Gowland C. Evaluative properties of measures used to assess patients with lateral epicondylitis at the elbow. Physiother Can 1993; 45:160 –4.

[74] Smidt N, Assendfelt WJ, Arola H, et al. Effectiveness ofphysiotherapy for lateral epicondyilitis: a systematic review. Ann Med 2003; 35: 51 –62.

[75] Bisset L, Paungmali A, Vicenzino B, Beller E. A systematic review and meta-analysis of clinical trials on physical interventions for lateral epicondylagia. Br J Sports Med 2005; 39:411 –22.

[76] Baker KG, Robertson VJ, Duck FA, et al. A review of therapeutic ultrasound: biophysical effects. Phys Ther 2001; 81:1351 –8.

[77] Bjordal JM, Couppe C, Chow RT, et al. A systematic review of low laser therapy with location-specific doses for pain from chronic joint disorders. Aust J Physiol 2003; 49:107 –16.

[78] Bjordal JM, Johnson MI. Transcutaneous electrical nerve stimulation (TENS) can reduce post-operative consumption. A meta-analysis with assessment of optimal treatment parameters for postoperative pain. Eur J Pain 2003; 7:181 –8.

[79] McLean S, Naish R, Reed L, et al. Apilot study of the manual force levels required to produce manipulation induced hypoalgesia. Clin Biomech 2002; 17(4):304 –8.