Comparison of effects of Cyriax physiotherapy, a supervised exercise programme and polarized polychromatic non-coherent light (Bioptron light) for the treatment of lateral epicondylitis

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Objective: To compare the effectiveness of Cyriax physiotherapy, a supervised exercise programme, and polarized polychromatic non-coherent light (Bioptron light) in the treatment of lateral epicondylitis.

Design: Controlled clinical trial.
Setting: Rheumatology and rehabilitation centre.
Subjects: This study was carried out with 75 patients who had lateral epicondylitis. They were allocated to three groups by sequential allocation.
Interventions: Group A (n = 25) was treated with Cyriax physiotherapy. A supervised exercise programme was given to group B (n = 25). Group C (n = 25) received polarized polychromatic non-coherent light (Bioptron light). All patients received three treatments per week for four weeks.
Outcomes: Pain was evaluated using a visual analogue scale and function using a visual analogue scale and pain-free grip strength at the end of the four-week course of treatment (week 4), one month (week 8), three months (week 16) and six months (week 28) after the end of treatment.
Results: The supervised exercise programme produced the largest effect in the reduction of pain and in the improvement of function at the end of the treatment (P < 0.05) and at any of the follow-up time points (P < 0.05).
Conclusion: The supervised exercise programme should be the first treatment option for therapists when they manage lateral epicondylitis patients. If this is not possible, Cyriax physiotherapy and polarized polychromatic non-coherent light (Bioptron light) may be suitable.

Introduction

Lateral epicondylitis, commonly referred to as tennis elbow, is one of the most common lesions of the arm. 1–3 It is usually defined as a syndrome of pain in the area of the lateral epicondyle. 3–6 The condition is a degenerative or failed healing tendon response characterized by the increased presence of fibroblasts, vascular hyperplasia and disorganized collagen in the origin of the extensor carpi radialis brevis (ECRB), the most commonly affected structure. 7 It is generally a work-related or...
sport-related pain disorder, usually caused by excessive quick, monotonous, repetitive eccentric contractions and gripping activities of the wrist. The dominant arm is commonly affected, with a prevalence of 1–3% in the general population and the peak prevalence is between 30 and 60 years. Lateral epicondylitis appears to be of longer duration and severity in women. The main complaints are pain and decreased function, both of which may affect activities of daily living. Diagnosis can be confirmed by tests that reproduce the pain, such as palpation over the facet of the lateral epicondyle, resisted wrist extension, resisted middle finger extension and passive wrist flexion.

No ideal treatment has emerged for the management of lateral epicondylitis. Many clinicians advocate a conservative approach. Physiotherapy is a conservative treatment that is usually recommended and a wide array of physiotherapy treatments are used: electrotherapeutic modalities, exercise programmes, massage and manual techniques. However, the sheer variety of physiotherapy treatments with such different theoretical mechanisms of action suggests that the optimal physiotherapy treatment strategy is not known and more research to establish the most effective physiotherapy treatment in lateral epicondylitis patients is needed.

Indeed, a cursory search of the literature revealed a systematic review published in 1992 that concluded that there was a lack of scientific evidence supporting physiotherapy treatments for lateral epicondylitis. Two recently published systematic reviews by Smidt et al. and Trudel et al. confirm these early findings and demonstrate the importance of improving the current physiotherapy management of lateral epicondylitis.

Two of the most common physiotherapy treatments for lateral epicondylitis are Cyriax physiotherapy and exercise programmes. There are two types of exercise programme: home exercise programmes and supervised exercise programmes carried out in a clinical setting. Home exercise programmes are rarely effective because patients fail to comply with the regimen. Only supervised exercise programmes appear to be at all effective. More recently, physiotherapists are able to use a new modality called polarized polychromatic non-coherent light (Bioptron light) for the management of lateral epicondylitis. Manufacturers of polarized polychromatic non-coherent light devices (Bioptron light, Bioptron, Wollerau, Switzerland) claim that the waves of this light move in parallel planes (polarization), cover a wide range of wavelengths (480–3400 nm) including visible light and part of the infrared range (polychromy), and are not synchronized (incoherence).

The clinical value of these three treatments for lateral epicondylitis is not known. Therefore, the aim of the present article was to make a comparison of the effects of Cyriax physiotherapy, a supervised exercise programme and polarized polychromatic non-coherent light for the treatment of lateral epicondylitis.

**Methods**

A controlled, monocentre trial was conducted in a clinical setting over an 18-month period to assess the effectiveness of Cyriax physiotherapy, a supervised exercise programme, and polarized polychromatic non-coherent light (Bioptron light). A parallel-group design was employed because cross-over designs are limited in situations where patients are cured by the intervention and do not have the opportunity to receive the other treatments following cross-over. Two investigators were involved in the study: (1) the primary investigator who administered the treatments (DS); (2) a specialized rheumatologist (IS), who had over 25 years’ experience and who evaluated the patients to confirm the lateral epicondylitis diagnosis, performed all baseline and follow-up assessments, and gained informed consent. All assessments were conducted by IS who was blind to the patients’ therapy group. IS interviewed each patient to ascertain baseline demographic and clinical characteristics, including patient name, sex, age, duration of symptoms, previous treatment, occupation, affected arm and dominant arm.

Abbott et al. suggest that a sample size of 25 subjects per group is sufficient to demonstrate statistical clinical significance for all outcome measures on lateral epicondylitis. Clinical effects...
of 20% had been reported as clinically meaningful in placebo-controlled studies measuring pain relief and functional outcomes in response to physiotherapeutic interventions such as low-power laser light. In this study, baseline variance for pain and functional outcomes was set at 25%. Power calculations suggested that a sample size of 25 patients per group was sufficient to detect a 20% change in outcome measures, assuming that variance was equivalent to 25% with 80% of power and a 5% significant level. The formula that used to estimate the appropriate sample size was:

$$N = \frac{16\sigma^2}{d^2}$$

where $\sigma^2$ is the variability of the data and $d^2$ is the effect size. For example in our trial $\sigma = 25$ and $d = 20$. Therefore the above formula is

$$N = \frac{16(25^2)}{(20^2)} = 16 \times \frac{625}{400} = 25$$

Patients over 18 years old who were suffering from lateral elbow pain were examined and evaluated in the rheumatology and rehabilitation centre located in Athens between January 2003 and January 2004. All patients lived in Athens, Greece, were native speakers of Greek, and were either self-referred or referred by their physician or physiotherapist.

Patients between 30 and 60 years old were included in the study if, at the time of presentation, they had been evaluated as having clinically diagnosed lateral epicondylitis for at least four weeks (one month). Patients were included in the trial if they reported (1) pain on the facet of lateral epicondyle when palpated, (2) less pain during resistance supination with the elbow in 90° of flexion rather than in full extension, and (3) pain in at least two of the following four tests:

1) Tomsen test (resisted wrist extension)
2) Resisted middle finger test
3) Mill’s test (full passive flexion of the wrist)
4) Handgrip dynamometer test

Patients were excluded from the study if they had one or more of the following conditions: (1) dysfunction in the shoulder, neck and/or thoracic region; (2) local or generalized arthritis; (3) neurological deficit; (4) radial nerve entrapment; (5) bilateral lateral epicondylitis; (6) limitations in arm functions; (7) pregnancy; (8) an installed pacemaker; (9) the affected elbow had been operated on and (10) had received any conservative treatment for the management of lateral epicondylitis in the preceding four weeks before entering the study.

All patients received a written explanation of the trial prior to entry into the study. All patients gave signed informed consent to participate in the study. The study was approved by the Leeds Metropolitan University Research Ethics Committee and access to patients was authorized by the manager of the rheumatology and rehabilitation centre.

The patients were allocated to three groups by sequential allocation. For example, the first patient with lateral epicondylitis was assigned to the Cyriax physiotherapy group, the second patient with lateral epicondylitis to the supervised exercise programme group, the third patient with lateral epicondylitis to the polarized polychromatic non-coherent light (Bioptron light) group, the fourth patient with lateral epicondylitis to the Cyriax physiotherapy group, and so on.

All patients were instructed to use their arm during the course of the study but to avoid activities that irritated the elbow such as shaking hands, grasping, lifting, knitting, handwriting, driving a car and using a screwdriver. Patients were informed to refrain from taking anti-inflammatory medication throughout the course of study. Patient compliance to this request was monitored using a treatment diary.

All treatments were administered at the centre by a qualified physiotherapist with a certificate in orthopaedic medicine on Cyriax principles (DS). Each treatment was given three times per week for four weeks.

Communication and interaction (verbal and non-verbal) between the therapist and patient was kept to a minimum and behaviours sometimes used by therapists to facilitate positive treatment outcomes were purposefully avoided. For example, patients were given no indication of the potentially beneficial effects of the treatments or any feedback on their performance in the pre- and postapplication measurements.

Cyriax physiotherapy was applied as presented by a recently published review article and consisted of 10 min of deep transverse friction immediately followed by one intervention of Mill’s
manipulation. Deep transverse friction is a specific type of connective tissue massage applied precisely to the soft-tissue structures such as tendons. Mill’s manipulation is a passive movement performed at the end of the elbow extension range (i.e. it consists of minimal amplitude high-velocity extension thrust at the elbow once the full range of elbow extension has been taken up). Cyriax physiotherapy treatment was individualized on the basis of the patient’s description of pain experienced during the procedure.

The supervised exercise programme consisted of slow progressive eccentric exercises of wrist extensors and static stretching exercises of ECRB tendon. Three sets of 10 repetitions of slow progressive eccentric exercises of wrist extensors at each treatment session were performed with 1 min rest interval between each set. Static stretching exercises of ECRB tendon were repeated six times at each treatment session, three times before and three times after the eccentric exercises with a 30-s rest interval between each repetition. Eccentric exercises of wrist extensors were performed with elbow on bed in full extension, forearm in pronation, wrist in extended position (as high as possible) and the hand hanging over the edge of the bed. From this position patients flexed their wrist, slowly counting to 30, then returned to the starting position with the help of the other hand. Patients were told to continue with the exercise even if they experienced mild pain. However, they were told to stop the exercise if the pain became disabling. When patients were able to perform the eccentric exercises without experiencing any minor pain or discomfort, the load was increased using free weights. Static stretching exercises of the ECRB tendon were performed with the help of the therapist. The therapist placed the elbow of patient in full extension, forearm in full pronation and the wrist in flexion and ulnar deviation according to the patient’s tolerance. This position was held for 30–45 s each time and then released. The supervised exercise programme treatment was individualized on one the basis of the patient’s description of pain experienced during the procedure.

Polarized polychromatic non-coherent light (Bioptron light) therapy was administered using a Bioptron 2 device to three locations for 6 min in each location (i.e. 18 min in total). Bioptron 2 is a product from Harrier Inc. USA, and was developed in Switzerland. The emission of light may be administered in 1-min steps and controlled by an integrated soft-start/soft-stop electronic switch. When the treatment with Bioptron 2 is over, there is a characteristic sound (beep tone). The output characteristics of Bioptron 2, according to the manufacturer’s user guide, are: light wavelength = 480–3400 nm; degree of polarization = 95%; specific power density = 40 mW/cm²; energy density = 2.4 J/cm². Bioptron 2 is approved by the US Food and Drug Administration, Therapeutic Goods Association Australia, EEC and carries an ISO 9001 certificate and EN 46001 as a patented medically approved product. The probe of the Bioptron 2 was held at a 90° angle 5–10 cm above the clean bare skin of the lateral condyle (1) from the upper surface (anterior) with the elbow in extension and the forearm in supination and (2) from the lateral surface with the elbow in 90° of flexion and the forearm in pronation. In addition, the probe of Bioptron 2 was held at a 90° angle 5–10 cm above the clean bare skin of the bellies of the extensors muscles of the wrist with the elbow in 90° of flexion and the forearm in mid-position of pronation–supination.

Pain, function and drop-out rate were measured in the present study. Each patient was evaluated at the baseline (week 0), at the end of treatment (week 4), at one month (week 8), at three months (week 16) and at six months (week 28) after the end of treatment.

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

Function was measured using a VAS, in which 0 (cm) was taken as ‘no function’ and 10 (cm) as ‘full function’. Patients were instructed to report their overall level of elbow function over the previous 24 h prior to each evaluation and this approach has been shown to be valid and sensitive of the VAS.

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

A drop-out rate was also used as an indicator of treatment outcome. Reasons for patient drop-out were categorized as follows: (1) a withdraw without reason; (2) not returned for follow-up; and (3) request for an alternative treatment.

The change from baseline was calculated for each follow-up for each outcome measure. Differences in this change pain on the VAS, change in function on the VAS and change in pain-free grip strength were calculated between the groups and was determined using a one-way analysis of variance (one-way ANOVA). Bonferroni post-hoc comparisons were conducted when the results from the one-way ANOVA were significant to determine how the three groups differed. A 5% level of probability was adopted as the level for statistical significance. SPSS version 11.5 statistical software was used for the statistical analysis.

Results

One hundred and twenty-one patients eligible for inclusion visited the clinic within the trial period. Twenty-five were unwilling to participate in the study and 21 did not meet the inclusion criteria described above. The other 75 patients were allocated by sequential allocation into one of the three possible groups: (1) Cyriax physiotherapy \( (n = 25; 16 \text{ male, } 9 \text{ female}; \text{ mean age } = 40.4 \text{ years } \pm \text{SD } = 5.6 \text{ years}) \), (2) a supervised exercise programme \( (n = 25; 15 \text{ male, } 10 \text{ female}; \text{ mean age } = 40.4 \text{ years } \pm \text{SD } = 5.6 \text{ years}) \) and (3) polarized polychromatic non-coherent light (Bioptron light) \( (n = 25; 15 \text{ male, } 10 \text{ female}; \text{ mean age } = 40.1 \text{ years } \pm \text{SD } = 6.2 \text{ years}) \). Patient flow through the trial is summarized in a CONSORT flow chart (Figure 1).

At baseline there were more males in the groups (17 in total). The mean age of patients was approximately 40 years and the duration of lateral epicondylitis was approximately five months. Lateral epicondylitis was in the dominant arm in 90% of patients. There were no significant differences in mean age \( (P < 0.0005, \text{ one-way ANOVA}) \) or the mean duration of complaints \( (P < 0.0005, \text{ one-way ANOVA}) \) between the groups. Patients had received a wide range of previous treatments (Table 1). Drug therapy had been tried by 30–45%. Some 4–8% of patients were athletes (Table 1).

Baseline pain on VAS was 6.9 cm (95% confidence interval \( \text{CI} = 6.7–7.1 \) for the whole sample \( (n = 75) \) (Table 2). There were no significant differences between the groups for baseline pain \( (P > 0.05 \text{ one-way ANOVA}, \text{ Table 2}) \). At week 4 there was a decline in VAS of approximately 4 units in all groups when compared with the pretreatment baseline \( (P < 0.0005, \text{ paired t-test}, \text{ Table 3}) \). There was a significant difference in the magnitude of reduction between the groups \( (P < 0.0005 \text{ one-way ANOVA}, \text{ Table 3}) \), so post-hoc tests were performed. The magnitude of reduction was significantly larger for the supervised exercise programme than for Cyriax physiotherapy \(+0.6 \text{ VAS units}) and polarized polychromatic non-coherent light \(+1.0 \text{ VAS units}, \text{ P } < 0.05, \text{ Bonferroni, Table 3})\). There was no significant difference between Cyriax physiotherapy and polarized polychromatic non-coherent light \(+0.4 \text{ VAS units}, \text{ P } > 0.05, \text{ Bonferroni, Table 3})\). Similarly, at weeks 8, 16 and 28 there were comparable magnitudes of reduction with larger reduction for the supervised exercise programme than for Cyriax physiotherapy and polarized polychromatic non-coherent light \( (P < 0.05, \text{ Bonferroni, Table 3}) \).

Baseline function on VAS was 3.9 cm (95% CI 3.74–4.13) for the whole sample \( (n = 75) \) (Table 2). There were no significant differences between the groups for baseline function \( (P > 0.05, \text{ one-way ANOVA}) \).
All lateral epicondylitis patients presenting the clinic \( (n = 121) \)

Unwillingness \( (n = 25) \)

Potential participants \( (n = 96) \)

Inclusion criteria

Not meeting inclusion criteria \( (n = 21) \)
Under 30 \( (n = 7) \)
Over 60 \( (n = 5) \)
Equal pain during resistance supination with elbow in 90° of flexion and extension \( (n = 4) \)
Lateral epicondylitis less than 4 weeks \( (n = 5) \)

Eligible patients \( (n = 75) \)

Sequential allocation \( (n = 75) \)

Cyriax physiotherapy \( (n = 25) \)  
Supervised exercise programme \( (n = 25) \)  
Bioptron light \( (n = 25) \)

Completed trial \( (n = 25) \)

Figure 1  Flowchart of the study.

Table 1  Previous treatments, occupations and duration of symptoms \( (n (%) ) \)

<table>
<thead>
<tr>
<th></th>
<th>Cyriax physiotherapy</th>
<th>Supervised exercise programme</th>
<th>Bioptron light</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Previous treatments</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Low-power laser light</td>
<td>4 (16%)</td>
<td>4 (16%)</td>
<td>4 (16%)</td>
</tr>
<tr>
<td>Drugs</td>
<td>10 (40%)</td>
<td>11 (44%)</td>
<td>9 (36%)</td>
</tr>
<tr>
<td>Ultrasound</td>
<td>5 (20%)</td>
<td>3 (12%)</td>
<td>5 (20%)</td>
</tr>
<tr>
<td>Iontophoresis</td>
<td>3 (12%)</td>
<td>2 (8%)</td>
<td>2 (8%)</td>
</tr>
<tr>
<td>Heat</td>
<td>0 (0%)</td>
<td>2 (8%)</td>
<td>2 (8%)</td>
</tr>
<tr>
<td>Injection</td>
<td>3 (12%)</td>
<td>3 (12%)</td>
<td>3 (12%)</td>
</tr>
<tr>
<td><strong>Occupations</strong></td>
<td></td>
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</tr>
<tr>
<td>Housework</td>
<td>9 (36%)</td>
<td>7 (28%)</td>
<td>7 (28%)</td>
</tr>
<tr>
<td>Manual work</td>
<td>7 (28%)</td>
<td>7 (28%)</td>
<td>8 (32%)</td>
</tr>
<tr>
<td>Secretarial</td>
<td>8 (32%)</td>
<td>9 (36%)</td>
<td>8 (32%)</td>
</tr>
<tr>
<td>Sport</td>
<td>1 (4%)</td>
<td>2 (8%)</td>
<td>2 (8%)</td>
</tr>
<tr>
<td><strong>Duration of symptoms</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under 5 months</td>
<td>7 (28%)</td>
<td>7 (28%)</td>
<td>6 (24%)</td>
</tr>
<tr>
<td>Over 5 months</td>
<td>18 (72%)</td>
<td>18 (72%)</td>
<td>19 (76%)</td>
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</table>
At week 4 there was a rise in VAS of approximately 3 units in all groups when compared with the pretreatment baseline (P < 0.0005, paired t-test, Table 3). There was a significant difference in the magnitude of improvement between the groups (P < 0.0005, one-way ANOVA, Table 3), so post-hoc tests were performed. The magnitude of improvement was significantly larger for the supervised exercise programme when compared with Cyriax physiotherapy (+7.1 pain-free grip strength units) and polarized polychromatic non-coherent light (+10.7 pain-free grip strength units, P < 0.05, Bonferroni, Table 3). There was no significant difference between Cyriax physiotherapy and polarized polychromatic non-coherent light (+3.6 pain-free grip strength units, P > 0.05, Bonferroni, Table 3). Similarly, at weeks 8, 16 and 28 there were comparable magnitudes of improvement, with larger improvements for the supervised exercise programme than for Cyriax physiotherapy and polarized polychromatic non-coherent light (P < 0.05, Bonferroni, Table 3). There was no significant difference between Cyriax physiotherapy and polarized polychromatic non-coherent light at any of the follow-up time points (P > 0.05, Bonferroni, Table 3).

There were no drop-outs and all patients successfully completed the study.

### Discussion

The results obtained from this controlled clinical trial are novel, as to date there have been no data comparing the effectiveness of Cyriax physiother-
<table>
<thead>
<tr>
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<th>Cyriax physiotherapy</th>
<th>Supervised exercise programme</th>
<th>Bioptron light</th>
<th>One-way ANOVA on change in VAS from baseline</th>
<th>Cyriax physiotherapy vs supervised exercise programme</th>
<th>Cyriax physiotherapy vs Bioptron light</th>
<th>Supervised exercise programme vs Bioptron light</th>
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<tr>
<td>Pain</td>
<td></td>
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<tr>
<td>Week 4</td>
<td>-4.1</td>
<td>-4.7</td>
<td>-3.7</td>
<td>( P &lt; 0.0005 )</td>
<td>+0.6 (*)</td>
<td>-0.4</td>
<td>-1 (*)</td>
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<tr>
<td></td>
<td>(-6 to -2)</td>
<td>(-6.8 to -2.4)</td>
<td>(-5.2 to -2.2)</td>
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<tr>
<td>Week 8</td>
<td>-4.3</td>
<td>-5.2</td>
<td>-4</td>
<td>( P &lt; 0.0005 )</td>
<td>+0.9 (*)</td>
<td>-0.3</td>
<td>-1.2 (*)</td>
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<tr>
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<td>(-7.1 to -2.6)</td>
<td>(-5.5 to -2.3)</td>
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<td>Week 16</td>
<td>-4.5</td>
<td>-5.8</td>
<td>-4.2</td>
<td>( P &lt; 0.0005 )</td>
<td>+1.3 (*)</td>
<td>-0.3</td>
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<td>(-5.7 to -2.8)</td>
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<td>Week 28</td>
<td>-5</td>
<td>-6</td>
<td>-4.4</td>
<td>( P &lt; 0.0005 )</td>
<td>+1 (*)</td>
<td>-0.6 (*)</td>
<td>-1.6 (*)</td>
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<tr>
<td>Week 4</td>
<td>+3.2</td>
<td>+3.9</td>
<td>+2.8</td>
<td>( P &lt; 0.0005 )</td>
<td>-0.7 (*)</td>
<td>+0.4</td>
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<td></td>
<td>(1.3 to 5.2)</td>
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<tr>
<td>Week 8</td>
<td>+3.4</td>
<td>+4.3</td>
<td>+3.1</td>
<td>( P &lt; 0.0005 )</td>
<td>-0.9 (*)</td>
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<td></td>
<td>(1.5 to 5.5)</td>
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<tr>
<td>Week 16</td>
<td>+3.7</td>
<td>+4.4</td>
<td>+3.3</td>
<td>( P &lt; 0.0005 )</td>
<td>-0.7 (*)</td>
<td>+0.4</td>
<td>+1.1 (*)</td>
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<td></td>
<td>(1.9 to 5.9)</td>
<td>(2.3 to 6.4)</td>
<td>(1.6 to 4.5)</td>
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<tr>
<td>Week 28</td>
<td>+3.9</td>
<td>+4.5</td>
<td>+3.4</td>
<td>( P &lt; 0.0005 )</td>
<td>-0.6 (*)</td>
<td>+0.5</td>
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<td>(2 to 6.1)</td>
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<td>(1.7 to 4.6)</td>
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<tr>
<td>Pain-free grip strength</td>
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<td>Week 4</td>
<td>+40.7</td>
<td>+47.8</td>
<td>+37.1</td>
<td>( P &lt; 0.0005 )</td>
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<td>+3.6</td>
<td>+10.7 (*)</td>
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<td></td>
<td>(28.9 to 52.2)</td>
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<tr>
<td>Week 8</td>
<td>+41.6</td>
<td>+49.7</td>
<td>+38.3</td>
<td>( P &lt; 0.0005 )</td>
<td>-8.1 (*)</td>
<td>+3.3</td>
<td>+11.4 (*)</td>
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<tr>
<td></td>
<td>(29.4 to 53.5)</td>
<td>(35.7 to 60.4)</td>
<td>(28.5 to 51.3)</td>
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<tr>
<td>Week 16</td>
<td>+42.2</td>
<td>+50.7</td>
<td>+39.4</td>
<td>( P &lt; 0.0005 )</td>
<td>-8.5 (*)</td>
<td>+2.8</td>
<td>+11.3 (*)</td>
</tr>
<tr>
<td></td>
<td>(29.5 to 53.8)</td>
<td>(37.2 to 61.9)</td>
<td>(29.2 to 51.8)</td>
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<tr>
<td>Week 28</td>
<td>+43.2</td>
<td>+51.5</td>
<td>+39.4</td>
<td>( P &lt; 0.0005 )</td>
<td>-8.3 (*)</td>
<td>+3.8</td>
<td>+12.1 (*)</td>
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<td></td>
<td>(30.2 to 54.7)</td>
<td>(37.9 to 62.7)</td>
<td>(29.5 to 52.1)</td>
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*The mean difference is significant at the 0.05 level.
Values are means (95% CI).
apy, a supervised exercise programme and polarized polychromatic non-coherent light for pain and function in lateral epicondylitis. The supervised exercise programme produced the largest effect in the short, intermediate and long term.

A home exercise programme was the sole treatment in only one previously published RCT, which was administered in a totally different manner than the supervised exercise programme employed in the present controlled clinical trial. The differences were not only in the environment in which the exercise programmes were administered, but also in the development of treatment protocol (type of exercises, intensity, frequency, duration of treatment). There is clearly a need for a future clinical trial to compare the effects of the present study’s supervised exercise programme treatment protocol with the home exercise programme treatment protocol used by Pienimaki et al.

Previously published trials found that a home exercise programme reduced the pain in patellar and Achilles tendinopathy, respectively. However, the home exercise programme was performed for about three months in all previously published studies. In contrast, the present controlled clinical trial and the study that was conducted by Stasinopoulos and Stasinopoulos administered a supervised exercise programme for a month. Thus, it seems that the supervised exercise programme may give good long-term clinical results in a shorter period of time than the home exercise programme. The most likely explanation for this difference may be that a supervised exercise programme achieves a higher degree of patient compliance. Future studies to compare the effects of these two exercise programmes are required to confirm the findings of the present controlled clinical trial.

The only previously published RCT that studied the effectiveness of Cyriax physiotherapy on lateral epicondylitis was conducted by Verhaar et al. They found that Cyriax physiotherapy was a less effective treatment than steroid injection in short-term follow-up (six weeks after the end of treatment), but they did not report whether either treatment was effective or ineffective in long-term follow-up (one year after the end of treatment), leaving the reader with questions about their effectiveness. In contrast, Cyriax physiotherapy was an effective treatment in the present controlled clinical trial, but it was less effective than the supervised exercise programme in the short, intermediate and long term.

Research on the effectiveness of Cyriax physiotherapy on overuse injuries is sparse, showing poor outcomes. However, these previously published studies had methodological shortcomings such as small sample size, lack of blinding (therapists, patients, assessors), lack of power analysis, invalid outcome measures, lack of follow-ups and lack of randomization. Thus, definite conclusions about the effectiveness of Cyriax physiotherapy cannot be drawn. In addition, in all previously published studies, Cyriax physiotherapy consisted of 10 min of deep transverse friction only, though Cyriax physiotherapy for lateral epicondylitis consists of deep transverse friction and Mill’s manipulation. One might question why, for other conditions similar to lateral epicondylitis, Cyriax physiotherapy should consist of deep transverse friction only and not of deep transverse friction plus Mill’s manipulation. Again, one might question why a similar manipulative manoeuvre is not recommended for the management of these other overuse conditions similar to lateral epicondylitis, for which deep transverse friction alone seems ineffective. Deep transverse friction and Mill’s manipulation showed positive effects on lateral epicondylitis in the present study and it is concluded that the effectiveness of Cyriax physiotherapy is based mostly on Mill’s manipulation. If a similar manipulation technique is found for other overuse injuries, the ineffective Cyriax physiotherapy treatment of these conditions may be rendered effective.

The present controlled clinical trial was the first study to examine the effectiveness of light therapy using polarized polychromatic non-coherent light (Bioptron light) on lateral epicondylitis. Two pilot studies assessed the effectiveness of this treatment in acute lateral epicondylitis and in carpal tunnel syndrome. The most likely explanation for the lack of trials is that polarized polychromatic non-coherent light has only become recently available in the physiotherapy area. All previously reported trials found that a course of polarized polychromatic non-coherent light treatment based on manufacturers’ claims may improve patients’ symptoms. The findings of these three trials
encourage the design of future well-designed RCTs that might produce strong evidence for the effectiveness of polarized polychromatic non-coherent light on overuse injuries.

Several trials have assessed the effectiveness of low-power laser light for the treatment of lateral epicondylitis. Although reviews of the literature found that low-power laser light is an ineffective treatment for lateral epicondylitis, this modality cannot be ruled out as a target for research because this is a dose–response modality and the optimal treatment dosage has not yet have been determined.\textsuperscript{6,41} Low-power laser light and polarized polychromatic non-coherent light differ in their radiation characteristics. Therefore, the effects of low-power laser light on lateral epicondylitis cannot be translated into those for polarized polychromatic non-coherent light. The effects of polarized polychromatic non-coherent light are yet to be confirmed by other researchers.

There were several shortcomings of the present trial. First, although this study was not a RCT, since no genuine randomization procedure was followed, the use of sequential allocation to allocate patients to treatment groups allowed for a true cause-and-effect relationship to be demonstrated. Second, no placebo (sham) or no treatment group was included in the present trial. The placebo (sham)/no treatment group is important when the absolute effectiveness of a treatment is determined. However, the absolute effectiveness of technique-based interventions is difficult to investigate, because a good and trustworthy placebo (sham)/no treatment control for Cyriax physiotherapy, exercise programmes and polarized polychromatic non-coherent light appears to be difficult or impossible to devise, due in part to difficulties in defining the active element of these treatments. In addition, there is strong evidence that lateral epicondylitis is not a self-limiting condition and patients’ symptoms cannot be reduced without appropriate ‘active’ treatment.\textsuperscript{9,37} Absolute effectiveness also does not provide the therapists with information as to which is the most appropriate treatment for the management of a condition, in this case lateral epicondylitis. Third, other activities treatments patients might be getting when not in the clinic were not monitored. Patients’ diaries suggested that patients were compliant to the study instructions, although patients may have given incorrect details to please the investigators. For example, it was possible that patients followed the treatment but took analgesic medications at the same time, and the improvement of symptoms may be due to those medications. Therefore, ways should be found to measure how other treatments such as analgesic medications contribute to the improvement of symptoms. Finally, the lack of standardization of treatment protocols for Cyriax physiotherapy and exercise programmes might be a possible shortcoming of the present controlled clinical trial. In order that study findings be generalized, it is essential that the type, intensity, frequency and duration of the treatment be sufficiently described in order to make it possible to replicate the therapy elsewhere.

In conclusion, Cyriax physiotherapy, a supervised exercise programme and polarized polychromatic non-coherent light reduced pain and improved function at the end of the treatment and at any of the follow-up time points. The supervised exercise programme produced the largest effect in the short, intermediate and long term and should be the first treatment option for therapists when they manage lateral epicondylitis.

Further studies on the possible mechanisms that can explain the effects of these treatments on lateral epicondylitis are also needed.

**Clinical messages**

- Cyriax physiotherapy, a supervised exercise programme and polarized polychromatic non-coherent light (Bioptron light) reduced pain and improved function at the end of the treatment and at any of the follow-up time points.
- The supervised exercise programme produced the largest effect in the short, intermediate and long term and should be the first treatment option for therapists when they manage lateral epicondylitis.
- Further studies on the possible mechanisms that can explain the effects of these treatments on lateral epicondylitis are also needed.
Further well-designed RCTs are needed to confirm the effectiveness of the treatments. In addition to
the analysis of the effectiveness of the compared
treatments, a cost-effectiveness analysis should be
incorporated in the trial, because reduced costs are
important issues for the recommendation of a
treatment. Finally, further studies on the possible
mechanisms the effects of these treatments on
lateral epicondylitis are also needed.

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