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Addition of isolated wrist extensor eccentric exercise to standard treatment for chronic lateral epicondylitis: A prospective randomized trial

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Background: Isokinetic eccentric training of the wrist extensors has recently been shown to be effective in treating chronic lateral epicondylitis. However, isokinetic dynamometry is not widely available or practical for daily exercise prescription. Therefore, the objective of this study was to assess the efficacy of a novel eccentric wrist extensor exercise added to standard treatment for chronic lateral epicondylitis.

Materials and methods: Twenty-one patients with chronic unilateral lateral epicondylitis were randomized into an eccentric training group (n = 11, 6 men, 5 women; age 47 ± 2 yr) and a Standard Treatment Group (n = 10, 4 men, 6 women; age 51 ± 4 yr). DASH questionnaire, VAS, tenderness measurement, and wrist and middle finger extension were recorded at baseline and after the treatment period.

Results: Groups did not differ in terms of duration of symptoms (Eccentric 6 ± 2 mo vs Standard 8 ± 3 mos., P = .7), number of physical therapy visits (9 ± 2 vs 10 ± 2, P = .81) or duration of treatment (7.2 ± 0.8 wk vs 7.0 ± 0.6 wk, P = .69). Improvements in all dependent variables were greater for the Eccentric Group versus the Standard Treatment Group (percent improvement reported): DASH 76% vs 13%, P = .01; VAS 81% vs 22%, P = .002, tenderness 71% vs 5%, P = .003; strength (wrist and middle finger extension combined) 79% vs 15%, P = .011.

Discussion: All outcome measures for chronic lateral epicondylitis were markedly improved with the addition of an eccentric wrist extensor exercise to standard physical therapy. This novel exercise, using an inexpensive rubber bar, provides a practical means of adding isolated eccentric training to the treatment of chronic lateral epicondylitis.

Level of evidence: Level I, Randomized Controlled Trial, Treatment Study.

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Keywords: Lateral epicondylitis; eccentric; physical therapy

Tennis elbow, or lateral epicondylitis, is a common condition that is characterized by pain at the lateral epicondyle, aggravated by resisted muscle contraction of the

carpi radialis brevis. The estimated annual incidence in the general population is 1-3%.^{2,9} A variety of specific treatment strategies have been described over the years, including bracing,^{10,19} corticosteroid injections,⁵ topical nitric oxide patch,¹⁵ repetitive low-energy shockwave treatment,^{6,16,18} surgery,¹⁴ and isolated eccentric training.⁸ Additionally, standard physical therapy includes wrist

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extensor stretching, isotonic wrist extensor strengthening, ultrasound, cross-friction massage, heat, and ice.²⁰

Isolated eccentric strength training has been shown to be effective for treating Achilles,^{1,12} patella,¹⁷ and shoulder tendonopathies.^{12,21} A common factor in the eccentric exercise programs utilized in these studies was that the exercises could be performed at home without the need for expensive equipment or regular physical therapy visits. Recently, isolated eccentric training was also shown to be effective in treating chronic lateral epicondylitis.⁸ However, the eccentric training utilized an isokinetic dynamometer, which necessitated patients coming to a clinic for treatments. Since isokinetic dynamometers are expensive and not widely available, this may not be a viable treatment option for many patients with chronic lateral epicondylitis. When home based isolated eccentric training with elastic resistance was used, it was not found to be more effective than stretching alone.¹³ Therefore, the purpose of this study was to assess the efficacy of a novel eccentric wrist extensor strengthening exercise added to standard treatment for chronic lateral epicondylitis.

Materials and methods

Twenty-one patients with chronic unilateral lateral epicondylitis participated in the study and were randomized into an Eccentric Group ($n = 11$, 6 men, 5 women; age 47 ± 2 yr) and a Standard Treatment Group ($n = 10$, 4 men, 6 women; age 51 ± 4 yr). (All subjects gave written informed consent and the protocol was approved by Institutional Review Board of the Lenox Hill Hospital, #L050648.)

Patients were included if they were diagnosed with lateral epicondylitis symptoms for greater than 6 weeks. Lateral epicondylitis was diagnosed using the following tests: (1) pain on palpation at the lateral epicondyle, (2) pain on resisted wrist extension, and (3) pain on resisted middle-finger extension. Subjects needed to test positive on all 3 tests to be included in the study.

Patients with a history of fracture, dislocation, surgery, bilateral elbow pain, cervical spine pathology, osteoarthritis, or previous steroid injection to the elbow less than 6 weeks prior were excluded.¹⁰ Two patients had prior physical therapy (1 in each group), 4 patients had a prior corticosteroid injections (3 in Eccentric Group, 1 in Standard Treatment Group), 1 patient had used a counterforce brace, and all patients had taken nonsteroidal anti-inflammatory medication. The remaining 13 patients had no prior treatment for their lateral epicondylitis. Ten patients developed lateral epicondylitis from playing tennis, 7 golf, 2 weight training, and 3 from activities of daily living.

Physical therapy treatment

All patients received wrist extensor stretching, ultrasound, cross-friction massage, heat, and ice during their physical therapy visits. Additionally, the Standard Treatment Group performed isotonic wrist extensor strengthening and the Eccentric Group performed isolated eccentric wrist

extensor strengthening. The strengthening and stretching exercises were also prescribed as a home exercise program. Treatments were continued until patients had resolution of symptoms or were referred back to their physician with continued symptoms. The isolated eccentric strengthening exercise was performed using a rubber bar (Thera-Band[®] FlexBar; The Hygenic Corporation, Akron OH) which was twisted using wrist flexion of the uninvolved limb and slowly allowed to untwist with eccentric wrist extension by the involved limb (Figure, A-E). Each eccentric wrist extensor contraction lasted approximately 4 seconds (ie, slow release). Both upper extremities were reset for the subsequent repetitions. A 30-second rest period was timed between each set of 15 repetitions and 3 sets of 15 repetitions were performed daily. Intensity was increased by giving the patient a thicker rubber bar if the patient reported no longer experiencing discomfort during the exercise.

Outcome measures

The Disability of Arm, Shoulder, and Hand Questionnaire (DASH) was used to determine the degree of disability caused by the lateral epicondylitis. Subjects were asked to report the pain level during their primary provocative activity. Pain was assessed using a Visual Analog Scale (VAS) graded from 0 to 10 (0 = no pain and 10 = severe pain). The DASH questionnaire and VAS were completed prior to and after the treatment period.

Strength testing

Wrist extension and middle finger extension strength were measured bilaterally with a hand-held dynamometer (Lafayette Manual Muscle Tester; Lafayette Instruments, Lafayette, IN). Wrist extension was tested with the forearm resting on a support surface and the hand in full wrist extension in a gravity resisted position. In this position a manual break test was performed with the dynamometer. Middle finger extension strength was tested with both the forearm and hand resting on a support surface. The middle finger was fully extended in a gravity resisted position and a break test was performed with the dynamometer. A smaller resistive pad was attached to the dynamometer for applying the resistive force during middle finger extension strength testing. The average of 3 repetitions was recorded for the involved and noninvolved sides for wrist extension and middle finger extension, and reported as percent deficits ($[(\text{noninvolved-involved})/\text{noninvolved}] * 100$).

Tenderness measurement

Tenderness was assessed using a probe attachment to the hand-held dynamometer. With the forearm on a supported surface, the probed was placed just distal to the lateral

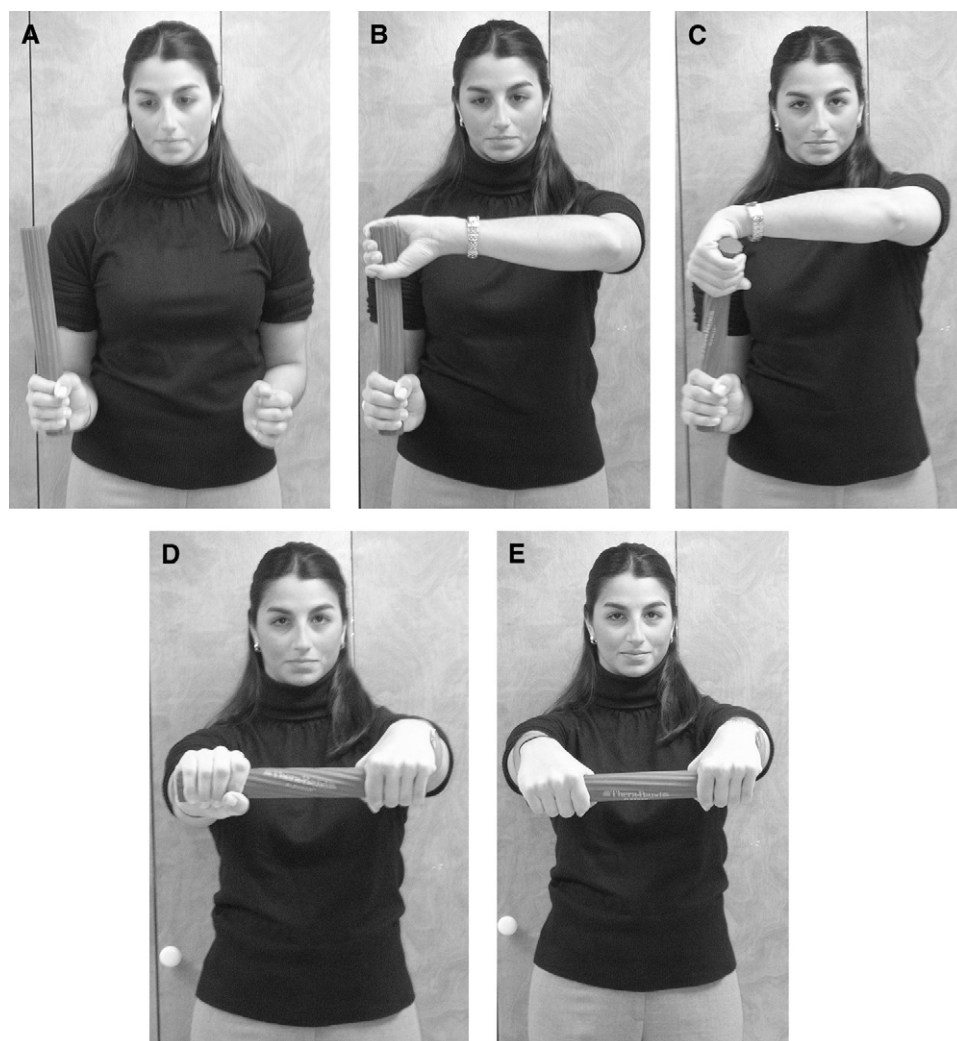


Figure (A) Rubber bar held in involved (right) hand in maximum wrist extension. (B) Other end of rubber bar grasped by noninvolved (left) hand. (C) Rubber bar twisted by flexing the noninvolved wrist while holding the involved wrist in extension. (D) Arms brought in front of body with elbows in extension while maintaining twist in rubber bar by holding with noninvolved wrist in full flexion and the involved wrist in full extension. (E) Rubber bar slowly untwisted by allowing involved wrist to move into flexion, ie, eccentric contraction of the involved wrist extensors.

epicondyle. Pressure was then applied and stopped at the point at which the patient reported discomfort. Three trials were performed on the involved and noninvolved sides and mean values were calculated. The percent deficit between the involved and noninvolved side was computed and reported as the measurement of tenderness $([(\text{noninvolved-involved})/\text{noninvolved}] * 100)$.⁷

All pre- and post-treatment outcome measures (DASH, VAS, strength, tenderness) were made by the same physical therapist, who was blinded to the patient's randomized treatment assignment and not involved in their direct care.

Statistics

Mixed model analysis of variance (ANOVA) with Bonferroni corrections for subsequent pairwise comparisons was

used to examine the effect of eccentric training on all dependent variables. Results are reported as mean \pm SD. The reliability of the strength and tenderness measurements was assessed by computing the standard error of the measurement (SEM) from the repeated tests (pre-treatment and post-treatment) on the noninvolved side. The absolute SEM and the SEM as a percentage of the mean strength and tenderness values is reported.

Based on previous work,²⁰ it was estimated that 15 patients per group would be sufficient to detect a 40% difference in DASH score improvement between groups at $P < .05$ with 80% power. Similarly, using previously published VAS pain data on patients with chronic lateral epicondylitis, it was estimated that a 20% difference in VAS pain (2 points on a 10 point scale) could be detected between groups at $P < .05$ with 80% power.⁸ These were the primary dependent variables.

Table Effect of eccentric training versus standard treatment of dependent variables

	Eccentric treatment		Standard treatment		Treatment by time
	Pre	Post	Pre	Post	
DASH (0-100)	38 ± 29	9 ± 21	38 ± 30	33 ± 22	<i>P</i> = .01
	Treatment effect	<i>P</i> = .002	Treatment effect	<i>P</i> = .33	
VAS pain (0-10)	6.7 ± 2.8	1.3 ± 2.7	6.3 ± 2.8	4.9 ± 2.7	<i>P</i> = .002
	Treatment effect	<i>P</i> = .0001	Treatment effect	<i>P</i> = .015	
Wrist extension strength deficit (%)	30 ± 11%	9 ± 23%	28 ± 19%	21 ± 25%	<i>P</i> = .18
	Treatment effect	<i>P</i> = .005	Treatment effect	<i>P</i> = .43	
Middle finger extension strength deficit (%)	17 ± 24%	1 ± 33%	12 ± 22%	13 ± 31%	<i>P</i> = .21
	Treatment effect	<i>P</i> = .18	Treatment effect	<i>P</i> = .84	
Combined strength deficit (%)	24 ± 15%	5 ± 20%	20 ± 16%	17 ± 18%	<i>P</i> = .011
	Treatment effect	<i>P</i> = .003	Treatment effect	<i>P</i> = .36	
Tenderness deficit (%)	51 ± 26%	15 ± 33%	40 ± 28%	38 ± 34%	<i>P</i> = .003
	Treatment effect	<i>P</i> = .005	Treatment effect	<i>P</i> = .82	

Mean ± SD reported.

Results

Demographics

There were 11 patients in the Eccentric Group (6 men, 5 women) and 10 patients in the Standard Treatment Group (4 men, 6 women). Groups did not differ in terms of age (47 ± 2 yrs vs 51 ± 4 yrs, $P = .32$), duration of symptoms (6 ± 2 wks vs 8 ± 3 wks, $P = .7$), number of physical therapy visits (9 ± 2 vs 10 ± 2 , $P = .81$) or duration of treatment ($7.2 \pm .8$ wks vs 7 ± 0.6 wks, $P = .69$).

Outcome measures

Improvements in DASH Scores were significantly better for the Eccentric Group versus the Standard Treatment Group (mean improvement 76% vs 13%, Treatment by Time $P = .01$; Table). In the Eccentric Group 5 patients had >90% improvement in DASH scores (100% = complete resolution of symptoms), 3 patients had 50-90% improvement in DASH scores, and 3 patients had <50% improvement in DASH scores. No patients in the Standard Treatment Group had >90% improvement in DASH scores, 3 patients had 50-90% improvement in DASH scores, and 7 patients had <50% improvement in DASH scores.

Pain

Similarly, improvement in VAS for pain was better for the Eccentric Group versus the Standard Treatment Group (mean improvement 81% vs 22%, Treatment by Time effect $P = .002$; Table). In the Eccentric Group, 6 patients had >90% improvement in VAS (100% = complete resolution of symptoms), 3 patients had 50-90% improvement, and 2 patients had <50% improvement. No patients in the

Standard Treatment Group had >90% improvement in VAS, 3 patients had 50-90% improvement, and 7 patients had <50% improvement.

Strength

Prior to treatment patients had marked weakness in wrist extension (deficit $29 \pm 3\%$, $P < .0001$). Improvement in wrist extension strength was not different between the Eccentric Group versus the Standard Treatment Group (Treatment Group by Time $P = .18$; Table). However, for the Eccentric Group, wrist extension strength deficits improved from $30 \pm 11\%$ to $9 \pm 23\%$ ($P = .005$) but did not improve for the Standard Treatment Group ($28 \pm 19\%$ to $21 \pm 25\%$, $P = .43$). Patients also had weakness in middle finger extension prior to treatment ($14 \pm 5\%$, $P = .008$). There was no apparent improvement in middle finger extension strength ($P = .17$), with no difference in strength change between the Eccentric and Standard Treatment Groups (Treatment Group by Time $P = .21$). However, the improvement in the combined strength deficit for wrist and middle finger extension was greater for the Eccentric Group ($24 \pm 15\%$ improving to $5 \pm 20\%$) than the Standard Treatment Group ($20 \pm 16\%$ improving to $17 \pm 18\%$, Treatment Group by Time, $P = .011$).

Tenderness

Prior to treatment the force required to elicit discomfort just distal to the lateral epicondyle was 39% lower on the involved side versus the noninvolved side ($P = .007$), indicating increased tenderness. Following treatment tenderness was reduced in the Eccentric Group (ie, it took a greater force to elicit discomfort) but unchanged in

the Standard Treatment Group (Treatment Group by Time, $P = .003$; Table).

Reliability

The SEM for wrist extension strength was 15.7 N, which was 10% of the mean value for the noninvolved side. The SEM for middle finger extension was 3.4 N, which was 23% of the mean value for the noninvolved side. The SEM for tenderness was 20.6 N, which was 19% of the mean value for the noninvolved side.

Discussion

The eccentric exercise program introduced in this study proved to be an effective method of treating chronic lateral epicondylitis. All outcome measures for chronic lateral epicondylitis were markedly improved with the addition of an eccentric wrist extensor exercise to standard physical therapy, compared with physical therapy without the isolated eccentric exercise. This novel exercise, using an inexpensive rubber bar, provides a practical means of adding isolated eccentric training to the treatment of chronic lateral epicondylitis. A prescription of 3 sets of 15 repetitions daily for approximately 6 weeks appeared to be an effective treatment in the majority of patients.

There are many different approaches to the treatment of chronic lateral epicondylitis, such as phonophoresis or iontophoresis,⁴ corticosteroid injections,⁵ extracorporeal shockwave therapy,^{6,16} topical nitric oxide,¹⁵ and bracing.³ These are commonly provided independently or as part of standard physical therapy. Compared to isolated eccentric strength training, treatments such as iontophoresis, phonophoresis, extracorporeal shockwave therapy, corticosteroid injections, or topical nitric oxide are expensive, require direct medical supervision, and, in some cases, have significant side effects. While the efficacy of isolated eccentric training for the treatment of tendinopathies in various joints has been clearly established,^{1,11,12,17,21} the additional benefit of this treatment is that it can be performed as part of a home program and does not involve continued medical supervision. Not only does this provide a cost benefit, but treatment dosage is not limited by the patient having to come to a clinic or needing direct supervision.

With respect to eccentric training for chronic lateral epicondylitis, Croisier et al⁸ compared isokinetic eccentric wrist extensor training to standard physical therapy. Pain reduction, disability questionnaire scores, and muscle strength were significantly better in the eccentric group. The effects of eccentric training on pain scores were very similar to the present study. Interestingly, the control groups in both studies also showed similar

changes in pain. Different disability questionnaires were used, and those results are not directly comparable. Additionally, Croisier et al⁸ chose not to measure wrist extension strength pre-treatment and only compared groups post-treatment, at which point the eccentric group were 1-10% stronger on the involved side while the standard treatment group were 28-38% weaker on the involved side. In the present study, the Eccentric Group was 9% weaker on the involved side post treatment while the Standard Treatment Group was 21% weaker on the involved side post-treatment.

The reliability data from the noninvolved side indicated that the wrist extension strength measurement was more reliable than the middle finger extension strength. Accordingly, the results showed significant changes in wrist extensions strength but no significant changes in middle finger extension strength. Thus the lack of effect on middle finger extension strength may be subject to a type II error.

An obvious limitation of the present study is the small sample size. Based on previous research, it was estimated that 15 patients per group would be needed to demonstrate a 40% difference in DASH score improvement between groups at $P < .05$ with 80% power; therefore, the goal was to recruit 15 patients per group. However, the physical therapists providing direct patient care anecdotally observed consistently poor outcomes for patients in the standard treatment group and consistently good results for patients in the eccentric group. Based on these observations, it was deemed appropriate to terminate the randomization, with 21 of the intended 30 patients having completed the study. This decision was based on the observation that patients in the Standard Treatment Group were having an unacceptably poor outcome. The subsequent data analysis supported this observation. None of the dependent measures showed a significant improvement in the Standard Treatment Group. By contrast, outcomes for the patients in the Eccentric Group were clearly good. Given the stark contrasts in outcomes between the Standard Treatment and Eccentric Groups, it was deemed unnecessary to continue the randomization. The poor results for the control group can be attributed to the limited provision of supervised physical therapy and reliance on unsupervised home program exercises. The average duration of treatment was approximately 7 weeks for both treatment groups; but, during this period, the average number of physical therapy visits was 9 for the eccentric group and 10 for the control group. Clearly, an average of 1.4 visits per week over 7 weeks was inadequate for the control group. Provision of additional supervised physical therapy may improve the results with standard treatment. Additionally, given that the follow-up period was only 7 weeks after the initiation of treatment, and that lateral epicondylitis has a high recurrence rate, the current results should be viewed as evidence for

short-term efficacy of eccentric strengthening. It remains to be determined if this treatment approach provides similar efficacy in the long term.

Conclusion

In conclusion, these data provide further evidence for the efficacy of eccentric training for tendinopathies. While isokinetic eccentric training has been shown to be an effective treatment for chronic lateral epicondylitis,⁸ this treatment option may not be available, may be too expensive, or may be impractical for many patients. By contrast, the novel eccentric exercise used in this study offers an inexpensive, practical treatment option with excellent results.

Disclaimer

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