Addition of a Novel Eccentric Wrist Extensor Exercise to Standard Treatment for Chronic Lateral Epicondylitis: A Prospective Randomized Trial

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ABSTRACT

Objective: 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.

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). Both treatment groups received wrist extensor stretching, ultrasound, cross-friction massage, heat and ice. Additionally the Standard Treatment Group performed isotonic wrist extensor strengthening and the Eccentric Group performed isolated eccentric wrist extensor strengthening. The eccentric exercise involved twisting a rubber bar (Thera-Band ® FlexBar, The Hygenic Corporation, Akron OH) with concentric wrist flexion of the noninvolved arm and slowly releasing the twist with eccentric wrist extension of the involved arm. Three sets of 15 repetitions were performed daily as part of a home program with intensity increased progressively during the treatment period. DASH questionnaire, visual analog pain scale (VAS), tenderness (measured with a myometer just distal to the lateral epicondyle), and wrist and middle finger extension strength (hand-held dynamometer) were recorded at baseline and after the treatment period. Treatment effects were assessed using Treatment (eccentric vs. standard) by Time (Pre vs. Post) ANOVA on each dependent variable. Based on previous work it was estimated that 15 patients per group would be sufficient to detect a 40% difference in DASH score improvement between groups at $P<0.05$ with 80% power. Mean±SE is reported.

Results: Groups did not differ in terms of duration of symptoms (Eccentric 6±2 mo vs. Standard 8±3 mo, P=0.7), number of physical therapy visits (9±2 vs. 10±2, P=0.81) or duration of treatment (7.2±0.8 wk vs. 7.0±0.6 wk, P=0.69). Improvements in all dependent variables were greater for the Eccentric Group versus the Standard Treatment Group (percent improvement reported): DASH 76% vs. 12%, P=0.01; VAS 81% vs. 22%, P=0.002, tenderness 70% vs. 4%, P=0.003; strength (wrist and middle finger extension combined) 72% vs. 11%, P=0.032.

Conclusions: All outcome measures for chronic lateral epicondylitis were markedly improved with the addition of an eccentric wrist extensor exercise to standard physical therapy. In fact, given the consistently poor outcomes for patients in the Standard Treatment Group it was deemed appropriate to terminate the randomization with 21 of the intended 30 patients having completed the study. This novel exercise, using an inexpensive rubber bar, provides a practical means of adding isolated eccentric training to the treatment of chronic lateral epicondylitis.

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% to 3%.[2;10] A variety of specific treatment strategies have been described over the years, including bracing[18], corticosteroid injections[5], topical nitric oxide patch[14], repetitive low-energy shockwave treatment[17], surgery[13] and isolated eccentric training.[8] Additionally, standard physical therapy includes wrist extensor stretching, isotonic wrist extensor strengthening, ultrasound, cross-friction massage, heat and ice.[19]

Isolated eccentric strength training has been shown to be effective for treating Achilles[1;11], patella[16] and shoulder tendonopathies[12] (for review see (20)). 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. 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.

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$\pm$2 yr) and a Standard Treatment Group (n=10, 4 men, 6 women; age 51$\pm$ 4 yr). Inclusion criteria were (1) a diagnosis of lateral epicondylitis with symptoms for greater than 6 weeks and (2) no prior surgical treatment for their lateral epicondylitis. The diagnosis of lateral epicondylitis was based on pain on the lateral side of forearm, which was aggravated with pressure on or just distal to the lateral epicondyle and with resisted wrist extension. Two patients had prior physical therapy (one 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 1 patient 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. All

subjects gave written informed consent and the protocol was approved by Institutional Review Board.

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 (Fig 1). Each eccentric wrist extensor contraction lasted approximately 4 seconds (i.e. 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. 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 the 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 are reported as percent deficits ([(noninvolved-involved)/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 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 ([(noninvolved-involved)/noninvolved] * 100).

Statistics:

Changes in DASH scores and VAS for pain from pre treatment to post treatment in the Standard Treatment Group versus the Eccentric Group were assess using Treatment Group (Eccentric vs. Standard) by Time (pre vs. post treatment) mixed model analysis of variance (ANOVA) with Bonferroni corrections for subsequent pairwise comparisons. For strength measures the percent deficit between the involved and noninvolved side was computed. Similarly, for tenderness the percent difference in the force required to elicit discomfort between the involved and noninvolved sides was computed. The changes in these strength and tenderness deficits from pre to post treatment between treatment groups were compared using Treatment Group by Time ANOVA.

The primary outcome measure in this study was the DASH score. Based on previous work[19] it was estimated that 15 patients per group would be sufficient to detect a 40% difference in DASH score improvement between groups at $P<0.05$ 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 $P<0.05$ with 80% power.[8] While myometer-based tenderness measurements have not previously been reported for patients with lateral epicondylitis this technique is commonly used in muscle damage studies. Based on reported inter-subject variability in the increase in biceps tenderness following damaging eccentric exercise [7] it was estimated that a 10 N difference between groups in the force required to elicit tenderness could be detected at $P<0.05$ with 80% power. Since the magnitude of tenderness could not be estimated it was not possible to more accurately assess the ability to detect a difference in change in tenderness between treatment groups. With regard to wrist extension strength Croisier et al[8] reported inter-subject variability in isokinetic wrist extensor weakness in patients with lateral epicondylitis. Assuming similar inter-subject variability with hand-held dynamometry measurements of wrist extensor weakness in this patient population it was estimated that a 20% difference in change in wrist extension strength deficit could be detected between groups at $P<0.05$ with 80% power. For example if both groups averaged a 40% deficit in

strength prior to treatment and one group improved to a deficit of 30%, the other group would have to improve to a 10% deficit for the between group difference to be significant at $P<0.05$ with 80% power.

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 yr vs. 51±4 yr P=0.32), duration of symptoms (6±2 wk vs.8±3 wk, P=0.7), number of physical therapy visits (9±2 vs. 10±2, P=0.81) or duration of treatment (7.2±0.8 wk vs. 7.0±0.6 wk, P=0.69).

Outcome Measures:

Improvements in DASH Scores were significantly better for the Eccentric Group versus the Standard Treatment Group (mean improvement 76% vs. 12%, Treatment by Time P=0.01; Fig. 2). 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=0.002; Fig. 3).

Strength:

Prior to treatment patients had marked weakness in wrist extension (deficit 29±3%, $P<0.0001$). Improvement in wrist extension strength tended to be greater in the Eccentric Group versus the Standard Treatment Group (Treatment Group by Time P=0.058, Fig. 4A). For the Eccentric Group wrist extension strength deficits improved from 30±3% to 12±6% (P=0.009) but did not improve for the Standard Treatment Group (28±6% to 26±6%, P=0.79). Patients also had weakness in middle finger extension prior to treatment (14±5%, P=0.008). There was no apparent improvement in middle finger extension strength (P=0.17) with no difference in strength change between the Eccentric Group and the Standard Treatment Group (Treatment Group by Time P=0.32, Fig. 4B). However, the improvement in the combined strength deficit for wrist and middle finger extension was greater for the Eccentric Group (24±5% improving to 7±5%) than the Standard Treatment Group (19±5% improving to 17±6%, Treatment Group by Time, P=0.032).

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 ($P=0.007$), indicating increased tenderness. Following treatment tenderness was reduced in the Eccentric Group (i.e. it took a greater force to elicit discomfort) but was unchanged in the Standard Treatment Group (Treatment Group by Time $P=0.003$; Fig. 5).

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.

There are many different approaches to the treatment of chronic lateral epicondylitis. Treatments such as phonophoresis or iontophoresis, corticosteroid injections, extracorporeal shockwave therapy, topical nitric oxide and bracing are commonly provided independently or as part of standard physical therapy. Baskurt et al [4] demonstrated similar improvements for phonophoresis versus iontophoresis in addition to standard physical therapy but did not compare them to standard physical therapy alone. Bisset et al[5] demonstrated short term benefits with corticosteriod injection versus standard physical therapy with no difference between treatments in the longer term. Chung et al[6] demonstrated no differences between extracorporeal shock wave therapy and a sham treatment. By contrast, Pettrone et al[15] demonstrated that low dose shockwave therapy was superior to placebo. The application of topical nitric oxide has been shown to be effective[14] but can cause side effects such as headache, weakness or dizziness, local skin irritation or rash at the application site, and cannot be used in patients with concomitant ischemic heart disease. Bracing has also shown some efficacy[3] and may be useful initially as an adjunct to 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;16;20] the additional benefit of this treatment is that it can be performed as part of a home program and it 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 al[8] 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. In the present study pre-treatment VAS in the Eccentric Group was 6.7±1.7, improving to 1.3±1.7 post treatment. For Croisier et al[8;9] pain improved from 6.9±1.5 pre treatment to 1.2±0.9 post treatment with eccentric training. Interestingly the control groups in both studies also showed similar changes in pain (Croisier et al[8] 6.7±1.5 pre treatment, 4.3±1.6 post treatment; current study 6.3±2.2 pre treatment, 4.9±2.1 post treatment). Different disability questionnaires were used and those results are not directly comparable. Additionally, Croisier et al[8] 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 were 12% weaker on the involved side post treatment while the Standard Treatment Group were 26% weaker on the involved side post treatment.

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 $P<0.05$ with 80% power. Therefore, the goal was to recruit 15 patients per group. However, given the consistently poor outcomes for patients in the standard treatment group 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 (12% improvement in DASH, P=0.34; 22% improvement in VAS, P=0.10; 4% improvement in tenderness, P=0.82; 6% improvement in wrist extension strength, P=0.79; 24% improvement in middle finger extension strength, P=0.66.). By contrast, outcomes for the patients in the Eccentric Group were clearly good. Again the data supported this observation (76% improvement in DASH, P=0.002; 81% improvement in VAS, P=0.0001; 70% improvement in tenderness, P=0.001; 60% improvement in wrist extension strength, P=0.009). Given the stark contrasts in outcomes between the Standard Treatment Group and the Eccentric Group it was deemed unnecessary to continue the randomization.

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], that 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.

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Figure 1A: Rubber bar held in involved (right) hand in maximum wrist extension.

Figure 1B: Other end of rubber bar grasped by noninvolved (left) hand.

Figure 1C: Rubber bar twisted by flexing the noninvolved wrist while holding the involved wrist in extension.

Figure 1D: 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.

Figure 1E: Rubber bar slowly untwisted by allowing involved wrist to move into flexion i.e. eccentric contraction of the involved wrist extensors.

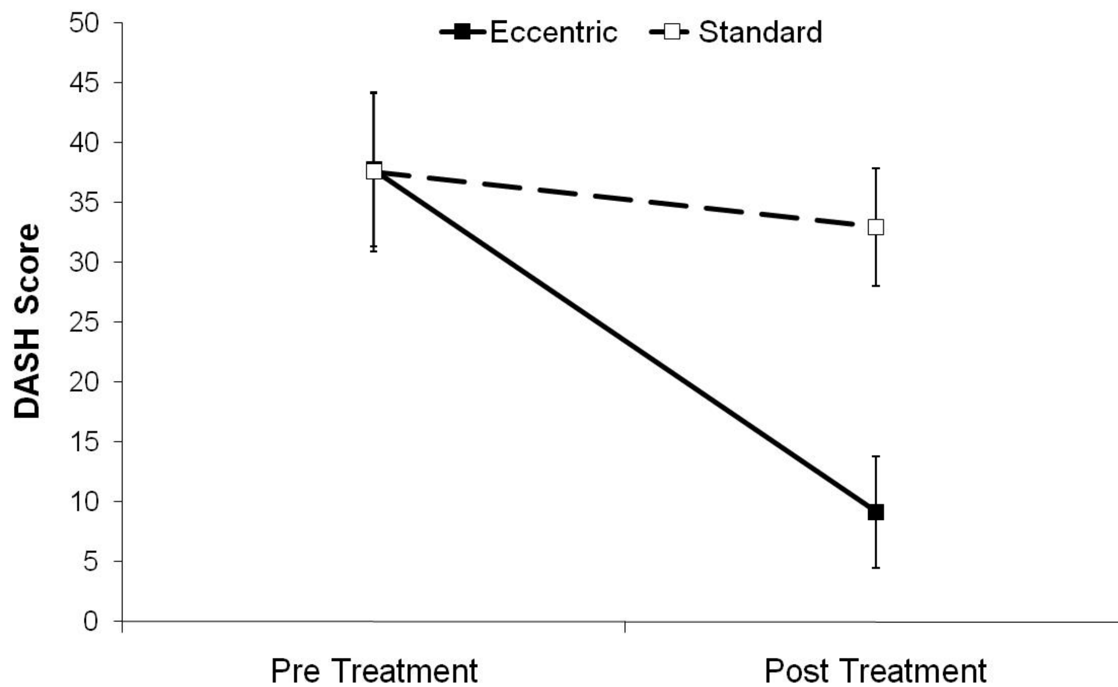

Figure 2: Changes in DASH scores from pre to post treatment in the Eccentric Group and the Standard Treatment Group. Effect of Time P<0.0001; Treatment Group by Time P=0.01. Post-treatment DASH lower in Eccentric Group versus Standard Treatment Group P<0.01. Mean ±SE displayed.

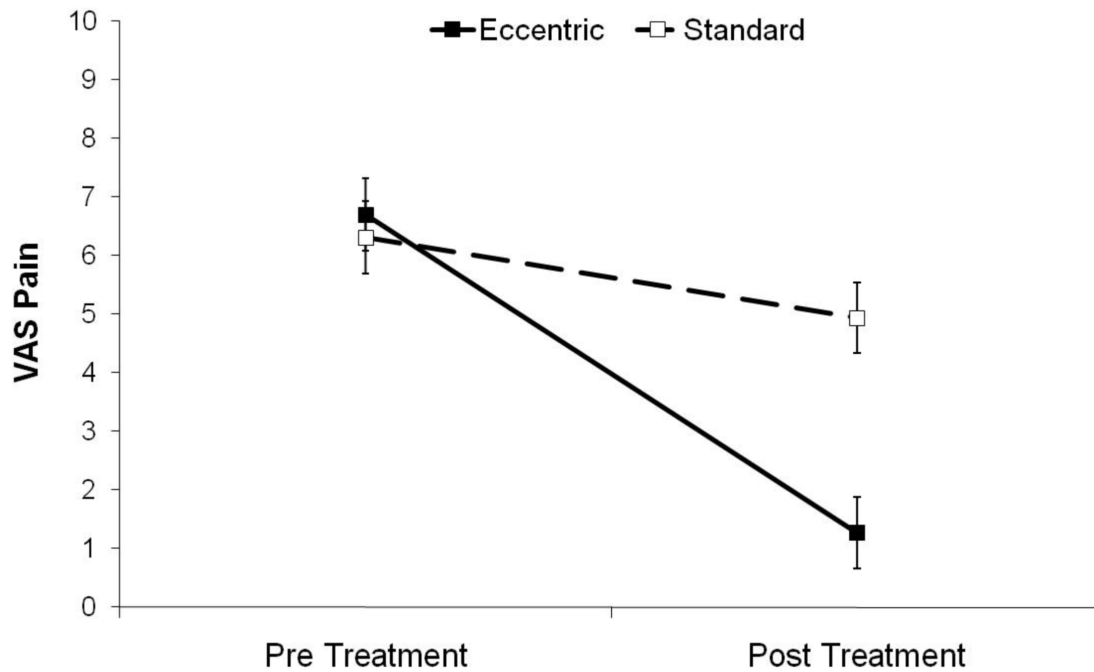

Figure 3: Changes in VAS for Pain from pre to post treatment in the Eccentric Group and the Standard Treatment Group. Effect of Time P<0.0001; Treatment Group by Time P=0.002. Post-treatment DASH lower in Eccentric Group versus Standard Treatment Group P<0.0001. Mean ±SE displayed.

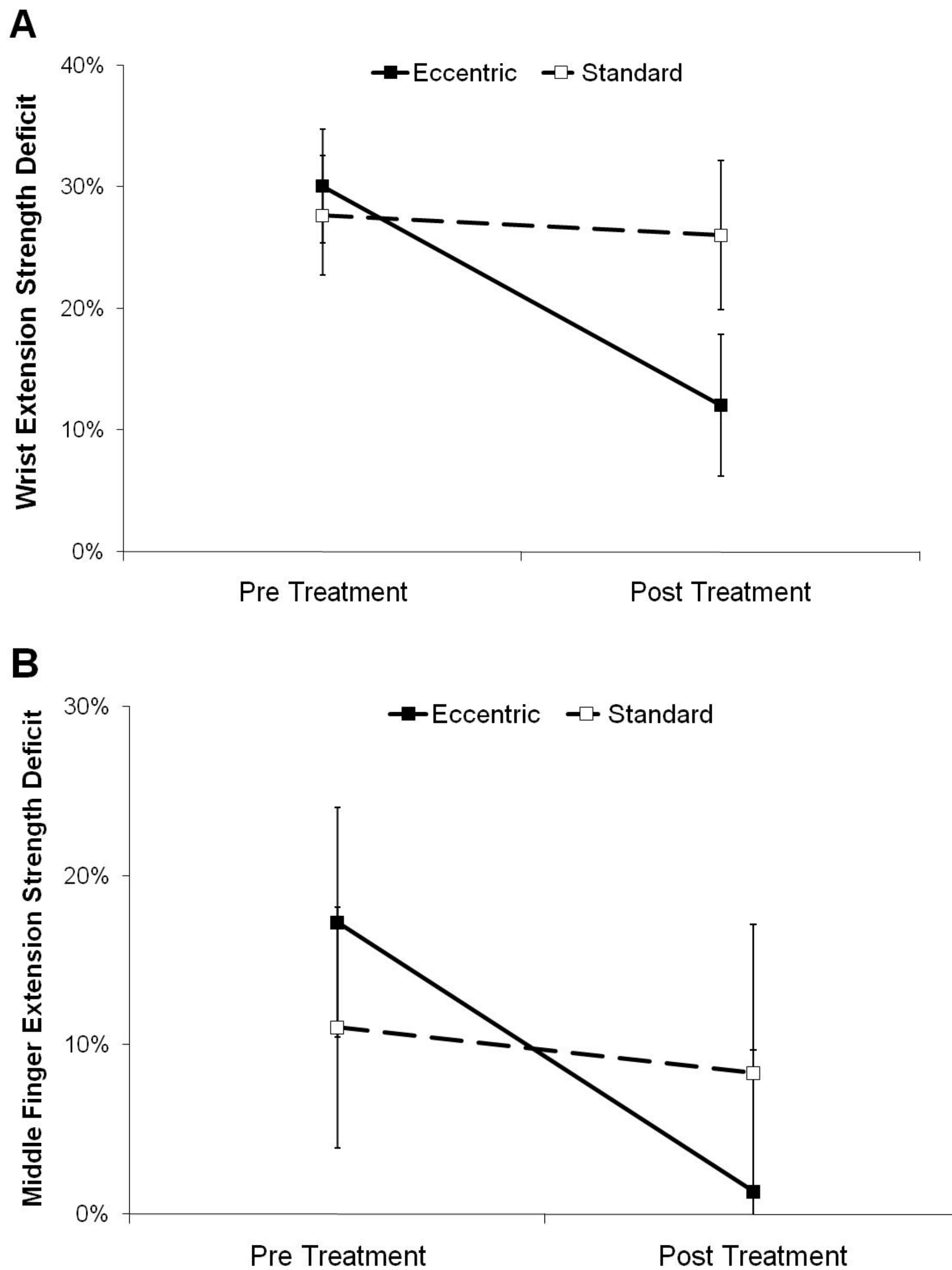

Figure 4: Changes in wrist extension strength deficit (A) and middle finger extension deficit (B) from pre to post treatment in the Eccentric Group and the Standard Treatment Group. Wrist extension: effect of Time P=0.026; Treatment Group by Time P=0.058. Middle finger extension: effect of Time P=0.17; Treatment Group by Time P=0.32. Combined strength deficit (wrist extension + middle finger extension): Time effect P=0.008; Treatment Group by Time effect P=0.032. Mean ±SE displayed.

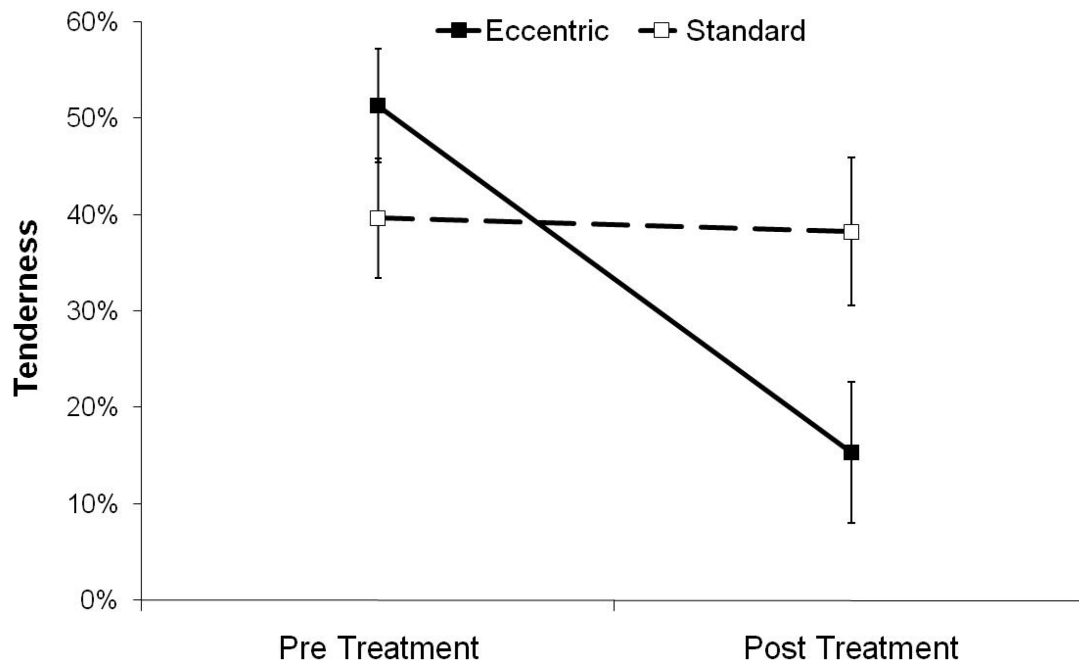

Figure 5: Tenderness just distal to the lateral epicondyle expressed as the percent deficit between the force required to elicit discomfort on the involved versus noninvolved side (a higher value indicates greater tenderness). Effect of Time P=0.002, Time by Treatment Group P=0.003. Mean ±SE displayed.

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