The Effect of Kinesio Tex Tape on Muscular Strength of the Forearm Extensors on Collegiate Tennis Athletes

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Abstract
Context: Tennis players, as a group, exhibit a 40% to 50% chance of being diagnosed with lateral epicondylitis at some point in their career. Kinesio Tape (KT) is a popular therapeutic application that is used by athletic trainers, physical therapists and physicians to increase stimulation of mechanoreceptors in order to facilitate muscular power/strength and decrease pain, edema, and inflammation. However, there is minimal research to support the therapeutic benefit of KT.

Objective: To determine if KT used in healthy collegiate tennis athletes is effective at decreasing fatigue by maintaining strength of the forearm extensors, which are commonly associated with lateral epicondylitis.

Design: Repeated-measures, counterbalanced design.

Setting: University Tennis Facility.

Patients or Other Participants: Fourteen (8 females, 6 males) healthy Division I tennis athletes.

Intervention(s): KT using a Y strip and no tape intervention.

Main Outcome Measure(s): The MicroFET2 was used to test the strength of the forearm extensors at pre-test, mid-test, and post-test of 65 slice backhands and 75 forehands preformed by each athlete.

Results: RM ANOVA for the interaction of measurement period by group showed that strength in the control condition was significantly decreased when compared to strength in the KT condition ($F=5.79$, $p=.032$). Percent change in strength between groups across measurement periods, using a Bonferonni correction, did not yield statistically significant differences: pre- to mid-test ($p=.094$), mid- to post-test ($p=.210$), or pre- to post-test ($p=.019$).

Conclusion: Our research indicates that KT, when applied to healthy collegiate tennis athletes, is associated with less of a decrease in muscular strength than that seen in a "no tape" condition. More research must be done to test if KT has a therapeutic benefit for athletes with chronic lateral epicondylitis.

Key Words: lateral epicondylitis, backhand, forehand

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Introduction:
Overuse or repetitive microtrauma to muscles, joints, ligaments and bones are common injuries seen in athletics. Repetitive stress at the elbow joint is a common chronic injury occurring in the tennis athlete. In Electromyographic (EMG) studies, performed on collegiate and professional tennis players, it was discovered that the wrist extensors, extensor carpi radialis brevis and longus and extensor digitorum, showed marked activity during portions of the serve, forehand and backhand strokes.[1,2] Therefore, with a marked increase in activation of the wrist extensors, a common type of overuse injury seen in the tennis athlete is lateral epicondylitis. Lateral epicondylitis has been given the nickname of "tennis elbow" because of the high risk for development while playing tennis. Research reveals that tennis athletes account for only 5% of those diagnosed with lateral epicondylitis but tennis players, as a group, exhibit a 40% to 50% chance of being diagnosed with lateral epicondylitis at some point in their career.[3-5]

Several treatment regimens are used in clinical practice for lateral epicondylitis, but there are only a small number of studies that support the effects of these interventions in the long term. The use of forearm bracing is another common method for treating athletes diagnosed with lateral epicondylitis. Forearm braces are often used as a counterforce action to decrease the overloading forces and therefore decrease the amount of tension placed on the tendon of extensor carpi radialis (ECR). Though many researchers are skeptical of the use of a forearm brace because it may restrict other musculature around the forearm, causing losses in circulation and motion.[4] In research conducted by Wuori et al[3], the Count'R-Force brace showed no significant difference in pain perception and functional outcomes when compared with two placebo braces (a neoprene elbow sleeve and a modified patellar strap).With more than 40 treatments to manage the symptoms of tennis elbow, research does not agree which treatment is the most effective.[6] The use of corticosteroid injections, non-steroidal anti-inflammatory drugs (NSAIDs), iontophoresis, progressive resistance exercise, ultrasonography, and acupuncture are common therapies, yet they appear to only provide a short term benefit.[7,8]

Kinesio Tape (KT) is a new and popular taping method proposed by Kenzo Kase, that claims to: 1) gather fascia to align the tissue in its desired position, 2) lift the skin over areas of inflammation, pain, and edema, 3) increase stimulation of the mechanoreceptors to either stimulate or limit movement, 4) provide a positional stimulus to the skin, and 5) decrease pressure over the lymphatic channels that provide a path for the removal of exudates.[9] Unlike conventional athletic tape, KT uses elastic properties to provide less muscular and blood flow restrictions. KT can also limit the amount of irritation to the skin, that is often present with conventional athletic tape, because it is latex free and uses heat activated adhesive to adhere to the skin. It has about the same thickness as the epidermis, to limit the body's sensory stimulus, and can be stretched between 55% and 60% of its resting length longitudinally.[9]

Despite its widespread popularity, minimal evidence exists to support the use of KT in the treatment of common musculoskeletal disorders. Research has found that KT immediately improves pain in active patients with rotator cuff tendonitis/impingement,[10] increases muscle bioelectrical activity 24 hours after tape application in healthy patients,[11] increases active range of motion of the lower trunk flexors,[12] aids in the functional motor skills of the upper extremity in a pediatric population.[13] On the contrary, research suggests that KT does not improve proprioceptive response at the ankle with measures of reproduction of joint position sense,[14] does not have an implication to decrease shoulder pain intensity or disability over time with patients with rotator cuff tendonitis/impingement,[10] does not improvement active lateral trunk flexion or extension range of motion,[12] and does not improve or worsen muscular performance in the posterior or anterior thigh of a healthy collegiate athlete.[15] However, there are no published randomized clinical trials that evaluate the effect of KT on delaying muscular fatigue in an athletic population during a bout of exercise.

Therefore, the purpose of this study was to determine if the use of KT, in healthy collegiate tennis athletes, is effective in decreasing fatigue by maintaining strength of the forearm extensors, which are associated with lateral epicondylitis. The investigator hypothesized that the KT condition will show a significantly less decrease in forearm extension strength than the control condition.

Methods:

Subjects

All subjects who participated in this study were current NCAA Division I collegiate tennis athletes or those who had participated in Division I collegiate tennis within 6 months of participation in the study. These athletes were chosen as subjects because they represent a young and elite population involved in repetitive and vigorous tennis practice and competition. In order to participate in this study, subjects were required to have no history of lateral epicondylitis within the past 4 months and were on the collegiate tennis roster within 6 months of the study. Exclusion criteria for this study included diagnosis of lateral epicondylitis within 4 months of the study, any known allergies to tape, and participation in rehabilitation for forearm pathologies at the beginning of the study. A cross-over experimental design was used to test all subjects in both the KT and control conditions. Before participating in the study, all subjects read and signed an informed consent form approved by the university's Institutional Review Board for the Protection of Human Subjects, which also approved the study.

Taping Techniques

All taping was conducted according to the manufacturer's recommendations.[9] Subjects were randomly assigned to participate in two conditions (control and KT) in a counterbalanced fashion. The KT group received the application for lateral epicondylitis of the elbow[9] using black 2 inch (5 cm) KT. (Figure 1) The subjects forearm was prepared for KT application using alcohol pads. The Kinesio Y strip was applied from insertion to origin, to inhibit muscle function in acutely over-used muscles, with paper-off tension, which refers to application of the tape directly to the skin from the paper backing.[9] The Kinesio Y strip is made from a single strip of tape with a cut down the middle to produce 2 equal size strips. This application decreases the strain placed on the over-used muscle by assisting with muscle contraction. The base of the Y strip was placed near the region of the radial styloid process with no added tension and rubbed in place to initiate glue adhesion. The elbow was placed in a position of slight flexion with the wrist in neutral. The first strip was applied using paper-off tension along the inferior aspect of the common wrist extensor muscle group to the lateral epicondyle of the humerus with paper-off tension. The second strip was applied using paper-off tension along the superior aspect of the common wrist extensor muscle group to meet the first strip at the lateral epicondyle where it was laid down with no tension. The strips were applied with the subject's arm in elbow and wrist extension and wrist ulnar deviation. The KT was applied 30 minutes prior to testing to allow the glue to become fully activated.[9]

Instrumentation

To measure the strength of the forearm extensors, the MicroFET2 (MF2) (Hoggan Health Industries, West Jordan, UT) was used to test the force, in Newtons, of wrist extension. An advantage of muscle testing using a hand-held dynamometer is the objectivity of the measurement and the consistency of results by a single tester over several tests and across multiple testers.[16] The muscle testing norm value for dominate hand wrist extension in women 20-29 years of age is 99.6 Newtons. The muscle testing norm value for dominate hand wrist extension in males 20-29 years of age is 184.3 Newtons.[17]

The MF2 includes three sizes of transducers heads for proper and comfortable contact to the extremity being tested. Pilot testing was performed to determine the intra-rater reliability and validity of the MF2, which was determined to be, an Interclass Correlation (ICC) (2,1) of 0.96 and a standard error of the mean(SEM) of 0.88.

Procedures

All testing took place at the collegiate tennis facility. A ball machine was pre-loaded and placed 2.87 meters from the baseline in the middle of the court (Figure 2). The interval, top spin, and elevation settings for the ball machine were pre-determined and settings kept constant for each subject. The number of forehand and backhand balls hit was predetermined from a testing session where two tennis athletes were to hit tennis balls until maximal fatigue. The two numbers were then averaged to come up with the number of balls used in this study. All subjects were required to attend two testing sessions so they could participate in both control and KT condition. Subjects were screened prior to testing to assure they met inclusion and exclusion criteria. Each subject completed a medical history questionnaire before testing began. All testing was conducted on the dominant arm as determined using the medical history questionnaire. The subject was seated on a chair with his/her forearm placed in a pronated position with the wrist in a neutral position on a flat surface (Figure 3). Before both sessions, the subject's strength was tested using the MF2. The subject applied an upward force for 5 seconds to the stationary MF2, which was placed on the dorsum of the wrist of the dominant hand and held in place by the principle investigator. Three trials were administered with a break of 15 seconds between trials for recording. The mean of the three trials was calculated and converted to Newtons for data analysis. The subject then drew a card labeled backhand slice or forehand, to determine which stroke was preformed first. Then the subject hit either 65 single-handed backhand slices or 75 forehands against a ball machine. Another test with the MF2 was done after the first series of balls were hit. After a 5 minute rest break the subject initiated the opposite stroke condition. The final test using the MF2 took place after the second series of tennis balls were hit with the designated stroke. Another testing session took place no more than one week after the first session. During the second session, the KT group switched to become the control group and the control group became the KT group.

Data Analysis

Data was analyzed using SPSS, Version 16.0 software (SPSS Inc, Chicago, IL). A 2-way Analysis of Variance (ANOVA) for repeated measures (RM) was used to test for an order effect and to compare the Kinesio Tape and control conditions. A multivariate approach was adopted in order to avoid problems associated with the violation of the sphericity assumption. The alpha level was set at $p = .05$. Interactions for the KT vs. control conditions and an order effect was tested. It was expected that the interaction of the order effect with condition would be insignificant and that data could be collapsed across the two different orders. If so, the Kinesio Tape vs. control condition could be analyzed using a post-hoc test. Percent change was also calculated from pre- to mid-test, mid- to post-test, and pre- to post-test. These values were analyzed using a standard matched-pairs t-test, with a Bonferroni correction (modified Hochberg). Using the correction that was purposed by Hochberg, the 3 p-values need to meet these criteria: 1) all three values <0.05 2) two values <0.025 or 3) one value <0.0167.

Results:
Fourteen subjects, eight females and six males, were enrolled in this study (age, 19.86 +-1.29 years; height, 177.50 +- 5.33 cm; weight, 70.33 +- 7.90 kg). The means and standard deviations of both groups for pre-test, mid-test, and post-test can be found in Table 1. An order effect was tested, but was found to be insignificant. RM ANOVA for the interaction (time by group), as seen in Figure 4, indicated that the control condition (Pre, 117.29 ±22.08; Mid, 105.21 ±18.87; Post, 100.02 ±17.72) showed a significant decrease (F=5.79, p=.032) in strength when compared to the KT condition (Pre, 118.03 ±27.05; Mid, 109.98 ±24.69; Post, 106.80 ±20.88). The main effect of measurement interval was significant: pre-(117.66±6.45), mid-(107.60±5.67), and post-test(103.41±4.92) (F=39.40, p≤.001). However, there was no significant difference in the main effect for group (CON, 107.51 ±5.13; KT, 111.60 ±6.40) (F=2.19, p=.163).

Percent change was calculated for pre- to mid-, mid- to post-, and pre- to post-test strength. Table 2 shows the percent decrease for both groups. Differences between groups for percent change in strength (Figure 5), were not significant using the Bonferonni correction: pre- to mid-test (t=1.81, p=.094), mid- to post-test (t=1.32, p=.210), pre- to post-test (t=2.69, p=.019).

Discussion:
The results of this study suggest that Kinesio Tape, when applied to healthy colligate tennis players, helps to maintain the strength of the forearm extensors. The reasons for this improvement may be related to physiological mechanisms by which KT is presumed to have a therapeutic benefit: 1) gather fascia to align the tissue in its desired position, 2) lift the skin over areas of inflammation, pain, and edema, 3) increase stimulation of the mechanoreceptors to either stimulate or limit movement, 4) provide a positional stimulus to the skin, and 5) decrease pressure over the lymphatic channels that provide a path for the removal of exudates.9 These physiological mechanisms still remain theoretical because there is limited research to support these concepts.

The greatest percent change between groups was from pre- to post- test. This may suggest that, as the motor units in the forearm extensors fatigued during the workout, the KT aids in muscle contractions. Our findings do not align with an EMG study[15] which found that KT did not change muscular power in the thighs and knees of healthy athletes. That study measured muscular power using an isokinetic machine. However, two studies measuring muscle activation after KT application found results similar to those of the current study. An EMG study by Slupik et al.,[11] measuring isometric contractions of the vastus medialis muscle, found an increase in bioelectrical activity 24 hours- 48 hours after KT application. Another study found an increase in muscle activation using EMG on baseball players diagnosed with shoulder impingement.[18] In this study, the investigators reported improved lower trapezium activity during 60 to 30 degrees of shoulder scaption and increased posterior tilt at both 30 and 60 degrees of shoulder scaption, when KT was applied to the lower trapezius. These studies support the current study; possibly suggesting that, as the forearm extensors fatigued, KT may have had an effect on recruiting additional motor units to the contracting muscle. More research should be done on the effects of muscular power and endurance over an extended period of athletic activity on a larger subject pool.

In addition to improvements in muscular strength and power, KT may have affected proprioception in the current study. In our study, KT was applied over the forearm extensors from insertion to origin for tendon correction. According to Kase et al[9], this technique will cause an increase in mechanoreceptor stimulation which is then perceived by the brain as a proprioceptive stimulation. However, a study by Halseth et al[14], found that KT does not affect joint position sense/proprioception at the ankle in healthy patients, as measured by a reproduction of joint position sense apparatus. In a study by Murray and Husk[20], it was found that KT, when applied to the ankle, caused an increase in joint position sense at 10° plantar flexion and therefore may have caused stimulation to the cutaneous mechanoreceptors. Still, the role of cutaneous and subcutaneous mechanoreceptors may have some effect on proprioception and neuromuscular control on injured patients who have a diminished sense of proprioception.[19] Theoretically, an external devise may cause stimulation of the cutaneous mechanoreceptors and enhance somatosensory proprioceptive input to joint receptors. However, there is still much controversy concerning the proprioceptive benefit of adhesive tape, braces, etc.[19] Further research in this area is required on athletes diagnosed with lateral epicondylitis to better test the activation of the cutaneous and subcutaneous mechanoreceptors on proprioception.

Another factor that may have played a role in this study is time from application of the tape to activity. The current study tested subjects 30 minutes after tape application, which was determined based on recommendation from Kase et al.[9] Slupik et al,[11] reported that KT application to the vastus medialis showed a significant increase in bioelectrical muscle activity 24-72 hours after initial application. However, there was not a significant increase in activity 10 minutes or 96 hours after initial application. This finding does not support the protocol set out by Kase et al,[9] that stated "The tape needs approximately 20 minutes to gain full adhesive strength." The current study tested subjects 30 minutes after tape application, and it may be inferred that the results would have differed if tape application were applied at least 24 hours before testing, as has shown to be effective in previous studies.

One of the potential limitations of this study is that the principle investigator had not completed a certified training session for the application of KT. The taping technique was reviewed and practiced several times by the investigator and all recommendations proposed by Kase et al[9] were followed. Therefore, it is unlikely that taping procedure would be significantly different when performed following KT certification. Another limitation of this study is the lack of blinding or a placebo group. Blinding participants to tape application is not feasible, but a placebo group, using a sham KT application, may have enhanced this study, but also may have led to subject dropout or a learning effect while using a cross-over study design. Finally, the use of healthy subjects, with no proprioceptive deficits from injury, limit the generalizability of the study results.

Future research should look at the effects of KT over a long period of time, such as a tennis match, to generate greater fatigue to the forearm extensor muscles. Another study should focus on the effects of KT on tennis athletes diagnosed with lateral epicondylitis to test the effect that KT may have on perceived pain and strength deficits.

Conclusion:
Our research indicates that KT, when applied to healthy collegiate tennis athletes, is associated with less of a decrease in muscular strength than that seen in a "no tape" condition. More research must be done to test if KT has a therapeutic benefit for athletes with chronic lateral epicondylitis.

Table 1. Group Means at Pre-, Mid-, & Post-Test

	Control	Kinesio Tape
Pre-Test	117.29±22.08	118.03±27.05
Mid-Test	105.21±18.87	109.98±24.69
Post-Test	100.02±17.72	106.80±20.88

Mean±SD in Newtons

Table 2. Mean Percent Decrease between Groups

	Percent Change (%)	p-Values
Kinesio Pre-Mid	-6.8±4.38	.094
Control Pre-Mid	-10.3±5.76	
Kinesio Mid-Post	-2.9±4.52	.210
Control Mid-Post	-4.9±5.25	
Kinesio Pre-Post	-9.5±6.22	.019
Control Pre-Post	-14.7±5.36	

Mean±SD
*Significance tested using Bonferroni correction (modified Hochberg). Hochberg criteria: 1) all three values <0.05 2) two values <0.025 or 3) one value <0.0167.

Figures Legend
Figure 1: Kinesio Taping Technique
Figure 2: Ball Machine Set-up
Figure 3: MicroFET2 Testing Procedure
Figure 4: Mean Strength and 95% Confidence Interval for Control and KT Conditions from Pre-, Mid-, and Post-Test

Figure 5: Percent Change in Strength and 95% Confidence Intervals between Pre-Mid-Test, Mid-Post-Test, and Pre-Post-Test for Control and KT Conditions

Figure 1:

Figure 2:

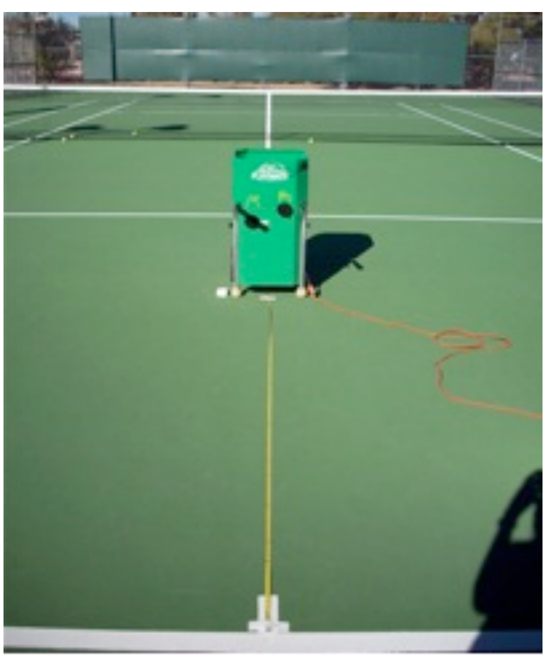


Figure 3: MicroFET2 Testing Procedure

Figure 4:

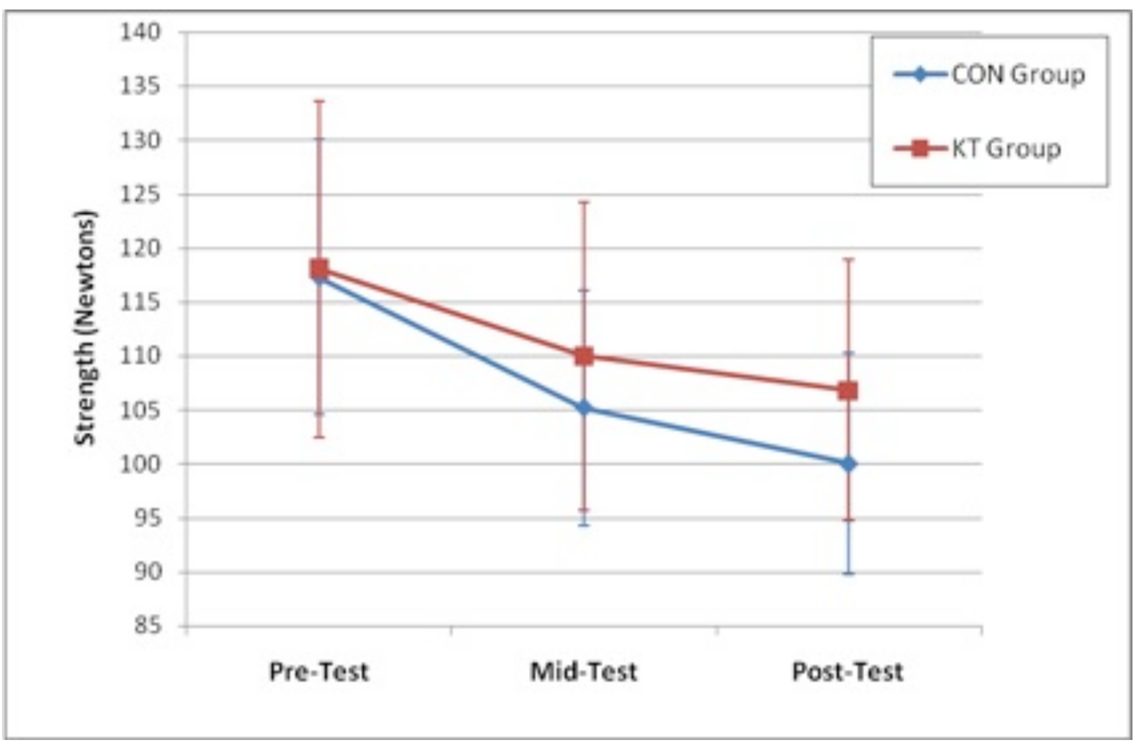
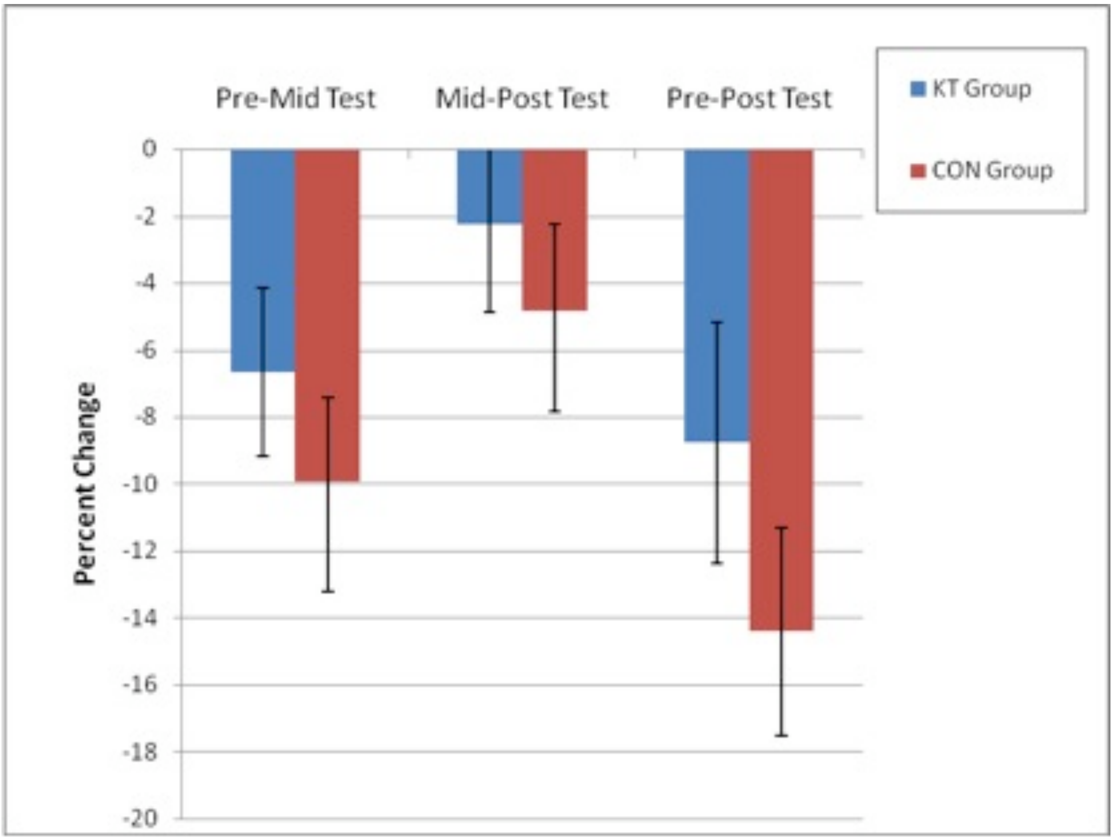


Figure 5:



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