2014

The Efficacy of Long-Term Kinesio Tape on Grip Strength in a Healthy Population

Neel Kotrappa
Claremont McKenna College

The Efficacy of Long-Term Kinesio Tape on Grip Strength in a Healthy Population

A Thesis Presented

by

Neel Somasundar Kotrappa

To the Keck Science Department

Of Claremont McKenna, Pitzer, and Scripps Colleges

In partial fulfillment of

The degree of Bachelor of Arts

Senior Thesis in Biology

4/21/2014

Dedication

I would like to dedicate my senior thesis to my family. This last year has thrown some very unexpected bumps in the road, and I am extremely grateful for your everlasting and genuine support and guidance through all of the good, but especially the rough times. I would never have been able to get through all of it without your unconditional love. Thank you for giving me the opportunity to attend an amazing college and allowing me to make all of the great memories that I have. To my mom, Kavitha, you've always worked so hard to give Megan and I all we have, and I could not be more grateful for your guidance, and pushing me to be the best I can. To my dad, Vijay, you have always been such a strong and constant presence in my life. Your love and excitement for life truly drives me to enjoy the little things around me. To my sister, Megan, you're an amazing smart, athletic, and caring young woman, and I cannot wait to see all of the great things that you will do in the years to come. Thank you all for being so supportive and coming out to my tennis matches for the past four years. It really does mean the world. I love you all!

I don't care how poor a man is. If he has family, he's rich.
- M.A.S.H.

TABLE OF CONTENTS

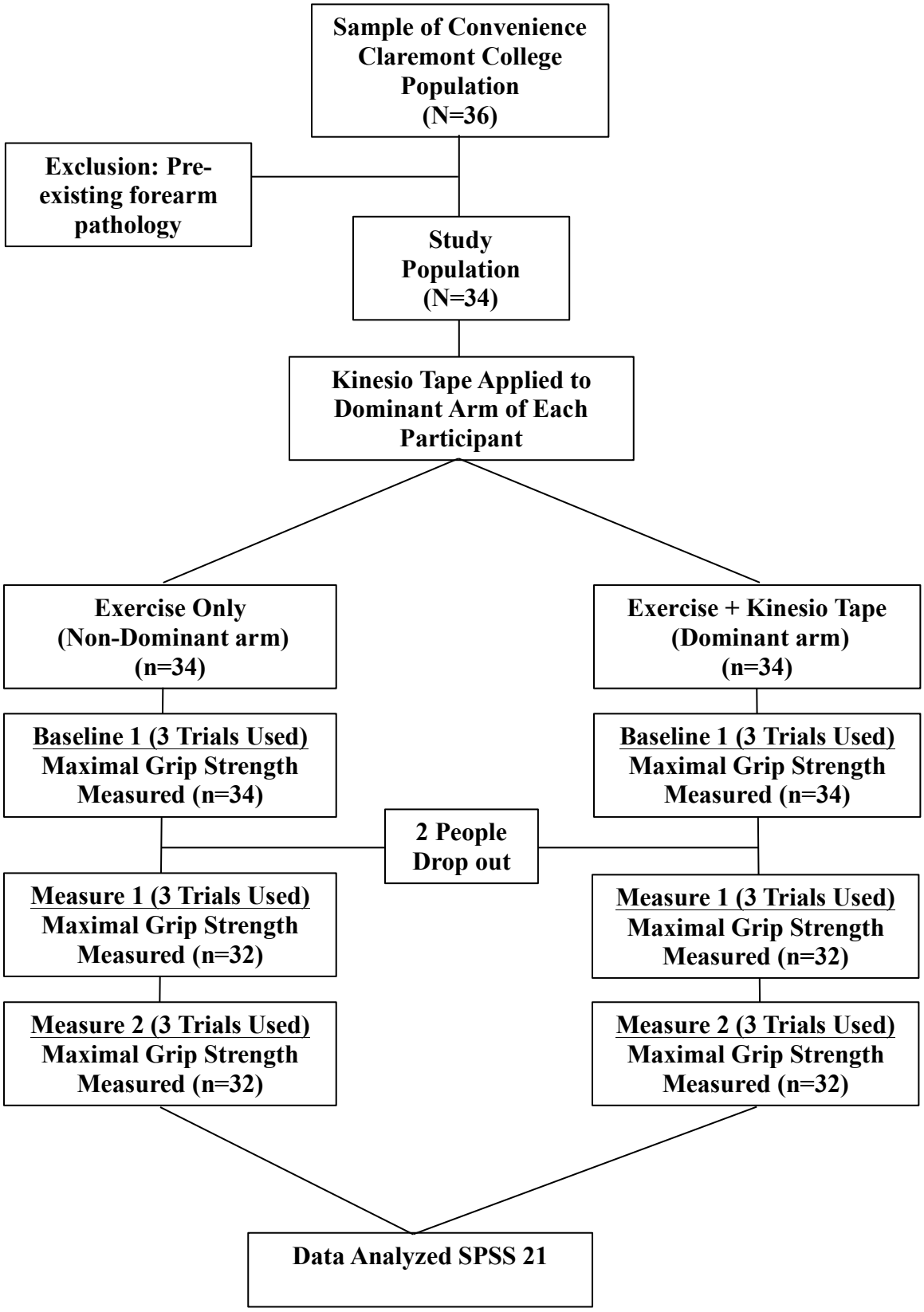


Figure 1. Overall Study Design

Abstract

Kinesio® Tape was invented in 1973, and since has been used in various clinical and therapy settings to prevent and heal a multitude of physical conditions. Kinesio® Tape is a 100% cotton-based elastic tape that when applied to the skin pulls the skin upwards and creates more space by lifting the fascia and soft tissue, thus increasing blood flow and decreasing edema. The tape was also purported to facilitate the strengthening of weakened muscles through neuromuscular facilitation. The objective behind this study was to determine the long-term effects of applied forearm Kinesio® Tape on maximal grip strength when paired with an exercise program. The study took place at the CMS Athletic Training Center, and was designed to be a matched-pairs, single group, repeated measures experiment. Thirty-two healthy members of the Claremont College community voluntarily participated in this study. There was 16 male and 16 female participants (average age: 21.46 ± 1.76 years; average height 174.92 ± 9.40 cm; average body weight 69.17 ± 9.20 kg). The maximal grip strength of both the dominant and non-dominant hands was measured using a JAMAR Hydraulic Hand Dynamometer. Each of the 32 subjects also participated in an exercise program for two weeks and provided a grip strength measurement at the end of each week. Maximal grip strength values were assessed using a standard paired-samples t-test. Results revealed a significant difference in grip strength in the dominant arm (exercise with Kinesio® Tape) compared to the non-dominant arm (exercise only). When combined with a relatively low to medium level exercise program, Kinesio® Tape significantly increased grip strength when compared to an exercise program alone in a healthy population.

Introduction

1.1. Background:

Kinesio® Tape was first created in 1973 by Japanese chiropractor Dr. Kenzo Kase (Kase, Wallis, & Kase, 2003) and since then, has been used to prevent and heal many different physical conditions. It was widely popularized in the 2008 Olympic Games by Kerri Walsh, Patty Schnyder, Phil Dalhausser and others (Talbott, 2008). Kinesio® Tape has since extended its reach to multiple disciplines, including clinical settings, through use by physical therapists, occupational therapists, chiropractors, massage therapists, and also in athletic settings, by athletic trainers, and both amateur and professional athletes.

Kinesio® Tape has been designed to mimic specific qualities of skin and is approximately the same thickness as the epidermis of the skin. The original Kinesio® Tape was modified slightly in 2010 to create a newer version of Kinesio® Tape, and has been designed to mimic more characteristics of the skin. It has a stretch potential ranging from 30-40 percent of its length in order to replicate the elastic quality of the skin. The tape itself is made of 100% cotton fibers, allowing for quick drying following water exposure and also the proper evaporation of body moisture. The adhesive used is 100% latex-free and is heat activated. It leaves behind no residue when removed. Although the thickness remains about the same (approximately the same thickness of the epidermis), the acrylic mounting of this new type of Kinesio® Tape differs from traditional white athletic tape in that it is designed with a wave-like grain. As the specialized grain and elasticity of the tape is applied to the skin, it provides a pulling force to the skin and

creates more space by lifting the fascia and soft tissue (Appendix C) under the areas where it is applied (Kase, Wallis, & Kase, 2003). “It was intended to limit the body’s perception of weight and not give a sensory stimuli that there was something on the skin when properly applied. After approximately 10 minutes, the patient will generally not perceive there is tape on the skin” (Kase, Wallis, & Kase, 2003). When compared to conventional rigid tape, Kinesio® Tape is significantly more elastic. The nonstretch rigid tape is used to limit unwanted joint movement or to protect and support a joint structure (Grelsamer & McConnell, 1998; Macdonald, 1994). However, data suggest that regular athletic tape does not in fact restrict joint movement. Bragg et al. in 2002 found that athletic tape loses its ability to restrict joint motion after 15–20 minutes of exercise. Therefore, the effects of taping may be due to the cutaneous stimulation of the sensorimotor and proprioceptive systems (Simoneau, Degner, Kramper, & Kittleson, 1997).

In Kenzo Kase’s manual, the authors describe six corrective techniques for clinical application: mechanical correction, fascial correction, space correction, ligament/tendon correction, functional correction, and lymphatic correction. When the application procedure is followed correctly, the taped area can be used to facilitate a weakened muscle or to relax an overused muscle. The method for applying the tape varies depending on the specific goals: improve active range of motion, relieve pain, adjust misalignment, or improve lymphatic circulation (Kase, Wallis, & Kase, 2003). Of these six applications, the space correction aspect is the most relevant to this study.

Although the other five applications are purported to induce positive effects on muscle function, this study will examine the purported effects of space correction.

1.2. Pain Management:

Space correction is used to alleviate pain in athletes by using the elastic qualities of the tape to lift the soft tissue and fascia, which creates more space under the skin and decreases pressure on the muscles. This technique also increases blood circulation, assisting in the reduction of pain and the removal of fluid or reduce edema. This property is particularly of interest, because previous studies have indicated that the recovery time of muscles and acute injuries is lessened when Kinesio® Tape has been applied (Nosaka, 1999; Zajit-Kwiatkowska, 2007).

First associated with pain management, the effect of Kinesio® Tape on muscular pain after exercise was examined by Nosaka in 1999, who found that all of the assessments used showed a tendency for Kinesio® Tape to control muscle damage and actually to assist in muscle recovery (Nosaka, 1999). Although due to limitations in the study, such as sample size, Nosaka called for further investigation to properly examine the true result of using Kinesio® Tape for musculoskeletal pain. In response, a study conducted in Europe examining multiple applications of Kinesio® Tape indicated that all injured persons' pain decreased and visible edema resorption occurred. This study concluded that the Kinesio® Tape: (1) Reduces the levels of pain suffered, (2) Increases the functional capabilities of the patient, (3) Constitutes a good method supplementing a regular physiotherapeutic treatment (Zajt-Kwiatkowska et al, 2007).

The rehabilitation effects of Kinesio® Tape were also investigated in an acute pediatric setting. Researchers used the Melbourne Assessment (Bourke-Taylor, 2003) in pre-taping and post-taping conditions to assess the improvement following the application of Kinesio® Tape. The Melbourne Assessment is an evaluation tool used to objectively measure unilateral upper limb function in children. The Melbourne Assessment is criterion referenced test for children between 5-15 years old with neurological impairment. The Melbourne Assessment was developed to measure change over time in children where change can be slow or subtle. The assessment scores the quality of unilateral upper limb motor function (Randall 1999). The study showed that there was a statistically significant ($p < 0.02$) improvement from pre- to post-taping. They concluded that the results indicated that Kinesio® Tape "may be associated with improvement in upper-extremity control and function in the acute pediatric rehabilitation setting" (Yasukawa et al., 2006).

Although there are plenty of articles documenting the positive effects of Kinesio® Tape, there have been studies that indicate that Kinesio® Tape might not have an effect on healthy subjects. Kinesio® Tape has been suggested to provide proprioceptive input in the acute phase of the injury process for lateral ankle sprain (Murray & Husk, 2001), but in another study, healthy subjects with good proprioception did not benefit from patellar taping of the knee joint (Callaghan, Selfe, Bagley, & Oldham, 2002). In this same study, patellar taping for healthy subjects with poor proprioception appeared to enhance proprioception.

1.3. Muscle Strength:

Dr. Kenzo Kase also claimed that one of the effects of Kinesio® Tape is to increase muscle strength (Kase, Wallis, & Kase, 2003). Research to test this assertion was conducted by Slupik et al., who examined the effect of Kinesio® Tape on changes in the tone of the vastus medialis muscle during isometric contractions. The results indicated an increase in the electromyographic activity of the vastus medialis muscle after 24 hours of Kinesio® Tape application. There was also an even maintenance of motor activity after 2 days of Kinesio® Tape application and following removal of the tape (Slupik et al, 2007). Although there was an increase in electromyographic activity in the muscle, further studies are necessary to fully document the benefits of Kinesio® Tape.

Kinesio® Tape had been shown to facilitate muscle effort on the muscles to which the tape is applied. The effects of Kinesio® Tape in Slupik's study was similar to the reports by a number of other researchers. For instance, Hsu et al. (2009) noted positive effects on both muscle activity and motion performance of scapular after Kinesio® Taping (Hsu et al., 2009). Furthermore, Kinesio® Tape was also claimed to cause improvement in certain modalities in clinical applications such as joint range of motion and proprioceptive stimulation. Another report mentioned the specific effect as the modulation of the skin mechanoreceptor. Additionally, after using Kinesio® Tape g on two anterior cruciate ligament reconstruction patients, the knee joint extension angle increased (Murray, 2001). Since Kinesio® Tape has an elastic property, it permits free joint motion. Such tape could offer a means to increase joint loading and activity of the

taped muscle, as well as to even out the movement and power of the joint during the performance of a vertical jump (Dye et al., 1999; Ernst et al., 1999; Powers et al., 1997).

In a study performed by Schneider et al. in 2010, collegiate tennis players were asked to wear Kinesio Tex Tape during physical activity to determine if Kinesio® Tape is effective at decreasing fatigue by maintaining strength of the forearm extensors. The results of this study indicated that Kinesio® Tape was associated with a smaller decrease in muscle strength when compared to no tape.

While there have been studies that have found evidence of the positive effects of Kinesio® Tape, other studies have found no significant effects of the tape. Fu et al. examined the effect of Kinesio® Tape on quadriceps strength and found that there was no significant difference in muscle strength immediately after tape application or after 12 hours of taping (Fu et al, 2008). There is still limited data on the positive effects of Kinesio® Tape on muscle strength.

1.4. Purpose:

The purpose of this experiment was to examine the long-term (2 week) effects of Kinesio® Tape on muscle strength. As there is limited research conducted on a Kinesio® Tape application period longer than 5 days, this study will provide valuable insight into the true effects of Kinesio® Tape on muscle strength. Rehabilitation centers and therapists use Kinesio® Tape to reduce edema and to increase blood flow to musculoskeletal injuries. These same principles are important following exercise, and a decrease in recovery time will theoretically help increase the gains and effects of physical

activity and exercise. Over a period of 2 weeks, the subjects will participate in a forearm strength program supervised by certified athletic trainers and will provide weekly grip strength measurements in addition to a baseline sample. The strength gains of the dominant arm (with Kinesio® Tape) and non-dominant arm (no taping) will be compared. It was hypothesized that the application of Kinesio® Tape on muscle combined with a strength training program would produce greater grip strength gains compared to a strength training program alone. The clinical significance of this study would be that Kinesio® Tape could be used to strength on weakened and healthy muscles faster in clinical, athletic, and professional settings.

Materials & Methods

2.1. Study Design and Participants:

The present study was conducted as a single blind, repeated measures design with a single matched pairs group. Thirty-four healthy male and female individuals voluntarily participated in this study. Both collegiate athletes and non-athletes were recruited as subjects from four colleges (Claremont McKenna College, Harvey Mudd College, Pitzer College, and Scripps College) using both email and Facebook. The age range of the participants was between 16 and 23 years (average age: 21.46 ± 1.76 years; average height 174.92 ± 9.40 cm; average body weight 69.17 ± 9.20 kg). All volunteers went through an initial screening process to ensure that no pre-existing musculoskeletal condition was present in the dominant and non-dominant arms within four weeks of the study. Exclusion criteria enforced during the screening included (1) elbow ligament injury, (2) elbow or wrist tendon injuries/tendonitis, (3) forearm muscle overuse/strain, (4) forearm fracture or nerve injuries within the past 3 months (Chang, 2010). The protocol of this study was approved by the Institutional Review Board of Claremont McKenna College in accordance with the currently applicable U.S. Public Health Service Guidelines. All participants understood the details of the study procedure and signed and informed consent prior to commencement of the study.

2.2. Taping Techniques:

In order to ensure that this study was conducted under similar protocols to previous studies, the taping techniques used were in accordance to the manufacturer's recommendations for lateral epicondylitis of the elbow (Kase, Wallis, & Kase, 2003). The

taping was applied to each participant's dominant arm, to ensure that previous activity with dominant/non-dominant arms would not interfere with the institution of the exercise protocol.

The skin on the forearm of each subjects' dominant arm was prepared for Kinesio® Tape application using alcohol pads to remove any oils, resins, and residue. Standard 2-in (5cm) black Kinesio® Tape (Kinesio Holding Company, Albuquerque, NM) was used to tape the wrist flexor muscle of the dominant arm. Prior to application of tape, the length of the forearm was measured, from the humeral wrist joint to 2 cm inferior of the lateral epicondyle, to determine the length of tape to be used. The standard 2-in tape was cut down the middle until the anchor-point, producing a Y-strip (Figures 2-3). The subjects were asked to place their wrists in a hyperextended position with the elbow in full extension. The base of the Y-strip was applied near the region of the radial styloid process with no tension and rubbed in place using the paper backing to initiate glue adhesion. The two tails of the Y-strip were then applied to the wrist flexor muscle with 15-20% stretch. The first strip was applied along the inferior aspect of the wrist flexor with the wrist in full hyperextension. The subject was then asked to relax his/her wrist and the second strip was then applied using 15-20% stretch to the superior aspect of the wrist flexor muscle. For each subject, Kinesio® Tape was applied approximately 30 minutes prior to baseline measurements in order to allow for the adhesive backing to become fully activated (Kase, Wallis, & Kase, 2003).

There was no placebo taping used in this experiment, as it was deemed unnecessary. For an experimental control, the non-dominant arm of each subject was used. Assuming activity level remained relatively constant for each subject from prior to the study through completion of the study, the initial difference in grip strength between dominant and non-dominant arms should be insignificant as only the percentage increase is measured. Each of

the thirty-four participants provided baseline grip strength measurements for both dominant and non-dominant arms. Subjects were asked to wear the Kinesio® Tape for the full duration of the study (15 days), with tape being reapplied as necessary when the adhesive on either of the tails or anchor points began to separate from skin. Kinesio® Tape was also worn during the baseline measurements, as well as during each exercise session and testing session with the hand dynamometer.

2.3. Exercise Protocol:

The subjects were asked to meet three times a week to participate in an exercise program focused on increasing grip strength. In order to decrease risk of injury and potential strains that accompany rigorous strength training, a more therapeutic approach was used. In order to simplify the exercise program, subjects were asked to complete the following one exercise with both dominant and non-dominant arms. TheraPutty® (Appendix D) was used as the means of providing resistance for this exercise. All exercises were performed under the supervision of certified athletic trainers.

Week 1: Two ounces of the lowest resistance level TheraPutty® (extra-extra soft) was used in this first week of exercise. The subjects rolled the putty into a cylindrical shape, approximately the same height as the width of their own hand. They then placed the putty into the palm of the dominant hand, and squeezed as hard as possible for 5 seconds. They then re-rolled the putty into a cylindrical shape and squeezed as hard as possible with the non-dominant hand for 5 seconds. This same procedure was repeated until the subject completed 15 repetitions with both dominant and non-dominant hand (Figure 4). Each participant performed 3 sets of 15 squeezes. Each set was followed by a 60 second rest period.

Week 2: The exercise protocol from Week 1 was repeated but with 2 oz. of a slightly higher resistance TheraPutty® (extra-soft). The subjects met the same three days as the previous week.

This specific TheraPutty® exercise was used because it most closely mimicked the motion used when generating grip strength measurements using the handheld dynamometer.

2.4. Outcome Measures:

The outcome measures for this study comprised of maximal grip strength measurements. Maximal grip strength was used in order to determine the strength of handgrip and strength of the wrist flexor muscle. A JAMAR Hydraulic Hand Dynamometer (Sammons Preston, USA) was used to measure grip strength. The measurements were taken with the subject sitting down, with the upper arm placed tight to the trunk, the elbow at 90^{o} flexion, and the wrist in a neutral and relaxed position (Figure 5). Participants were asked to hold the hand dynamometer and grip the handle of the dynamometer as hard as possible for 3 seconds. Three trials were conducted for each arm, and the mean values were recorded for further analysis. The reliability test for the hand dynamometer was examined in a previous study by Bohannon, which indicated that there is an intra-class correlation coefficient (r^2) of 0.973.

2.5. Statistical Analysis:

In order to determine the effects of Kinesio® Tape on long-term outcomes related to grip strength, a standard Matched Pairs T-Test was used. The differences in grip strength for the different measurement periods for dominant/non-dominant were used as the pairs. The independent variable was the training program with two sublevels: with Kinesio® Tape and

no tape. The dependent variable was maximal grip strength. The level of statistical significance was set at $p < 0.05$. Analysis was also done to analyze the grip strength differences between male and female participants. Analysis of the data was conducted using the Statistical Package for the Social Sciences (SPSS, Version 21; SPSS Inc, Chicago, IL).

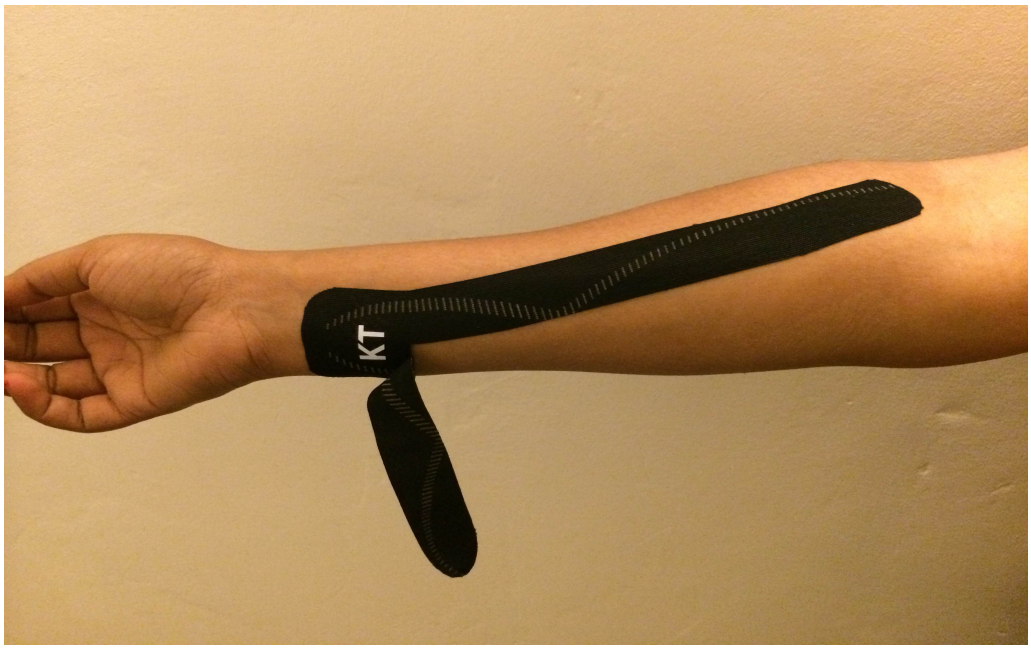


Figure 2. First Y-Strip of Kinesio Tape applied to the middle of the forearm from insertion to origin with 15-20% stretch tension (Own picture).

Figure 3. Kinesio Tape fully applied to the common wrist flex muscle from insertion to origin with 15-20% stretch (Own picture).

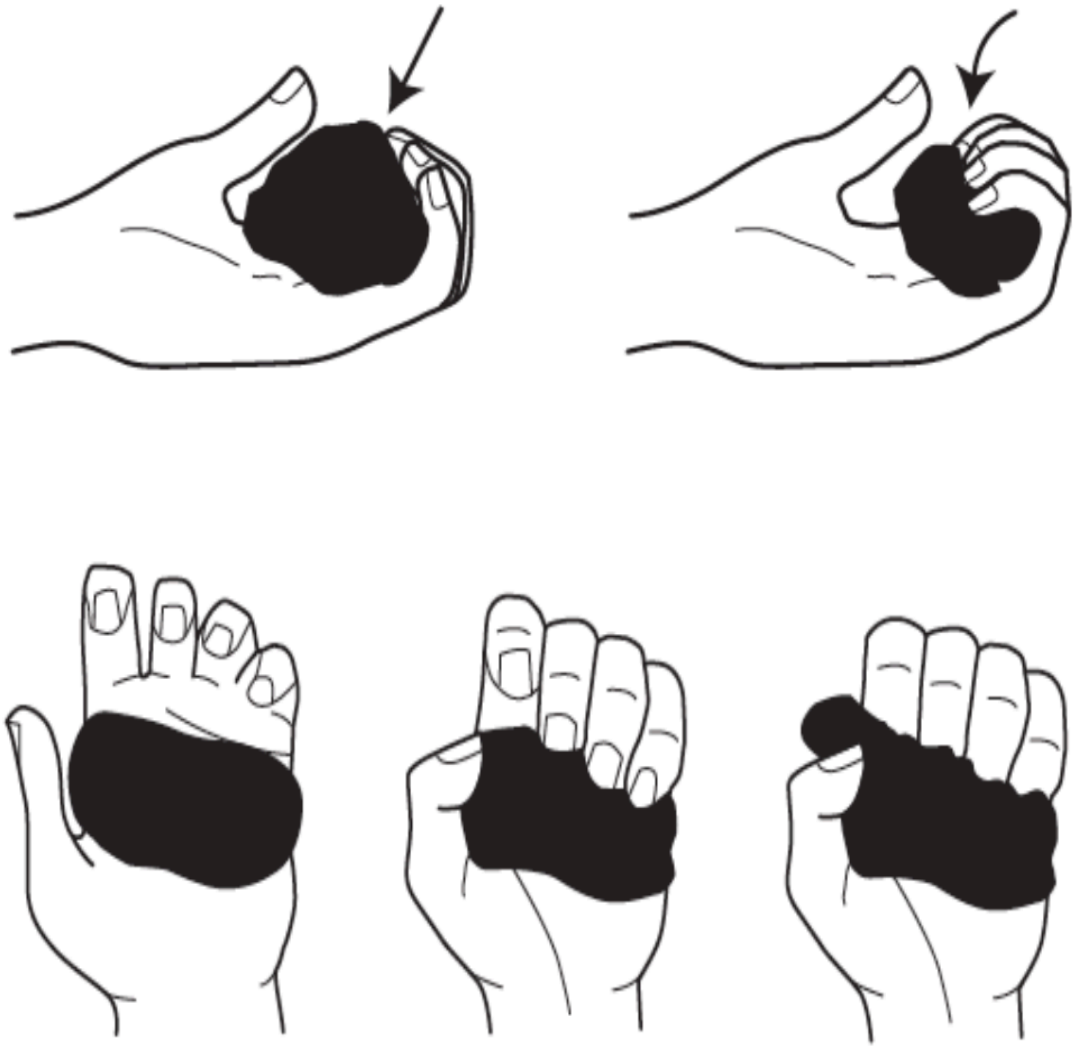


Figure 4. Theraputty exercises to be performed by each subject. Each subject performed three sets of fifteen repetitions (15 x 3) with each arm. Exercises were performed during week 1 with extra, extra-soft resistance putty and extra-soft resistance putty during week 2 (Own picture).

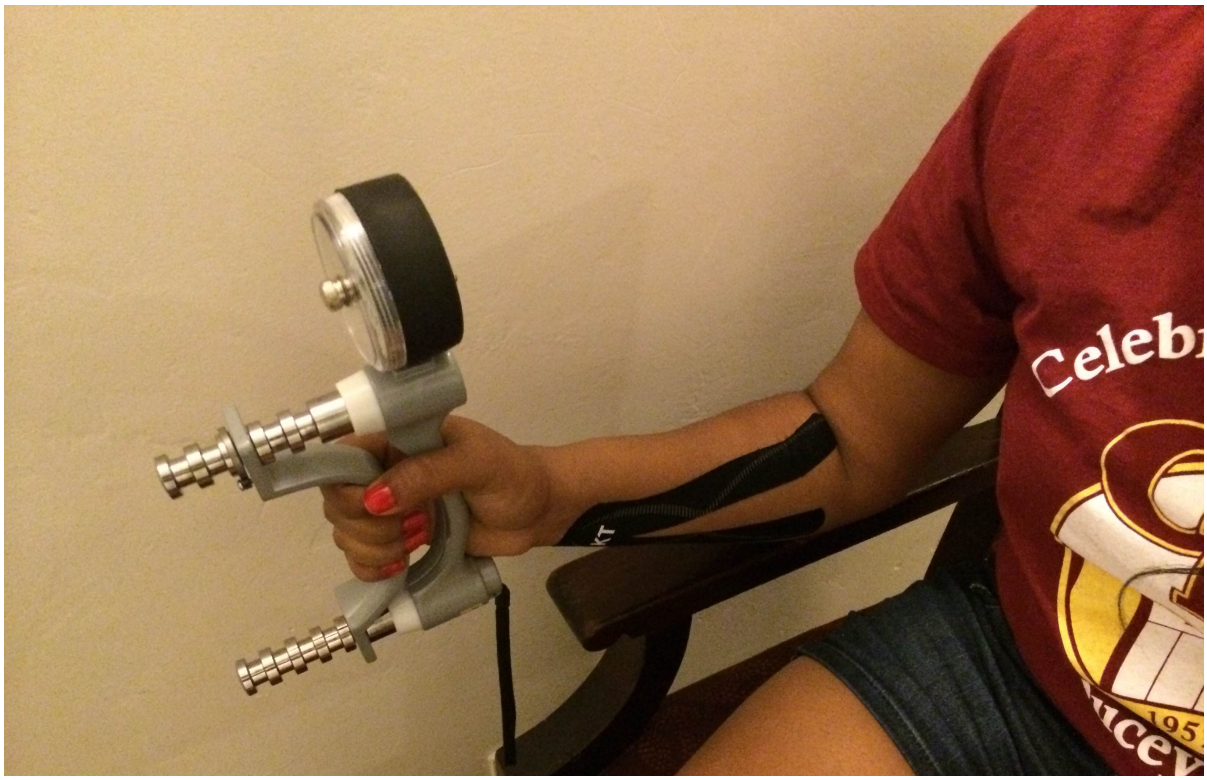


Figure 5. Arm and body testing position for grip strength measurements using the JAMAR Hydraulic Hand Dynamometer (Own picture).

Results

3.1. Presentation of Results:

Two participants were dropped from the study for failing to report to the Week 1 grip strength readings, which brought the number of participants to 32.

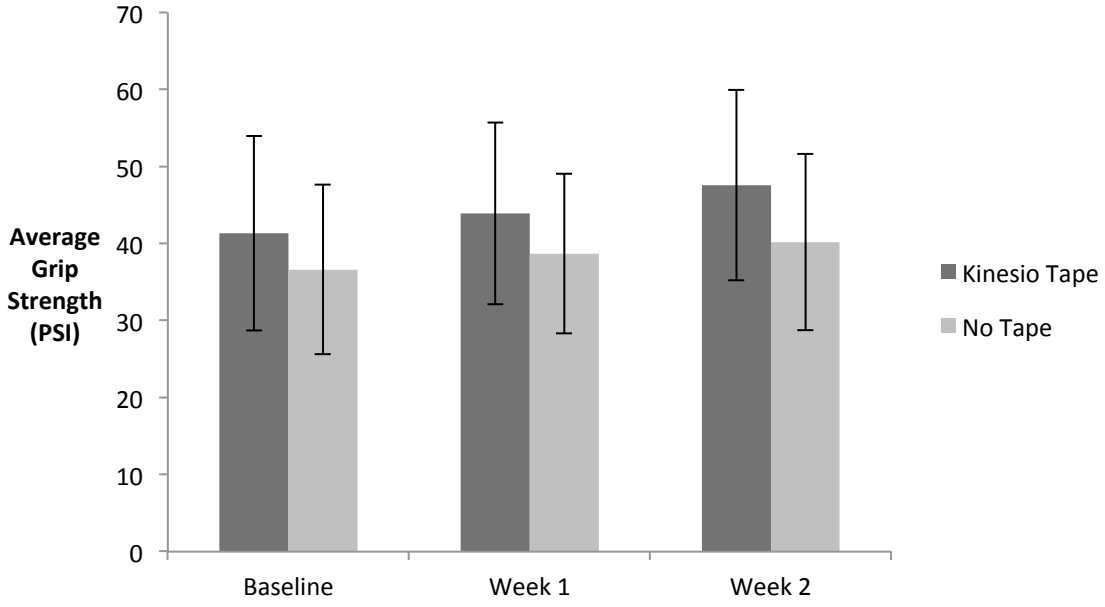


Figure 6. Average grip strength ± SD for dominant (Kinesio® Tape) and non-dominant (no tape) arms for the baseline, week 1, and week 2 grip strength readings (n = 32).

Average grip strength increased in each of the three grip strength measurements from 41.312 to 43.906 to 47.594 PSI in the dominant (with Kinesio® Tape) arm and 36.625 to 38.469 to 40.219 PSI in the non-dominant arm.

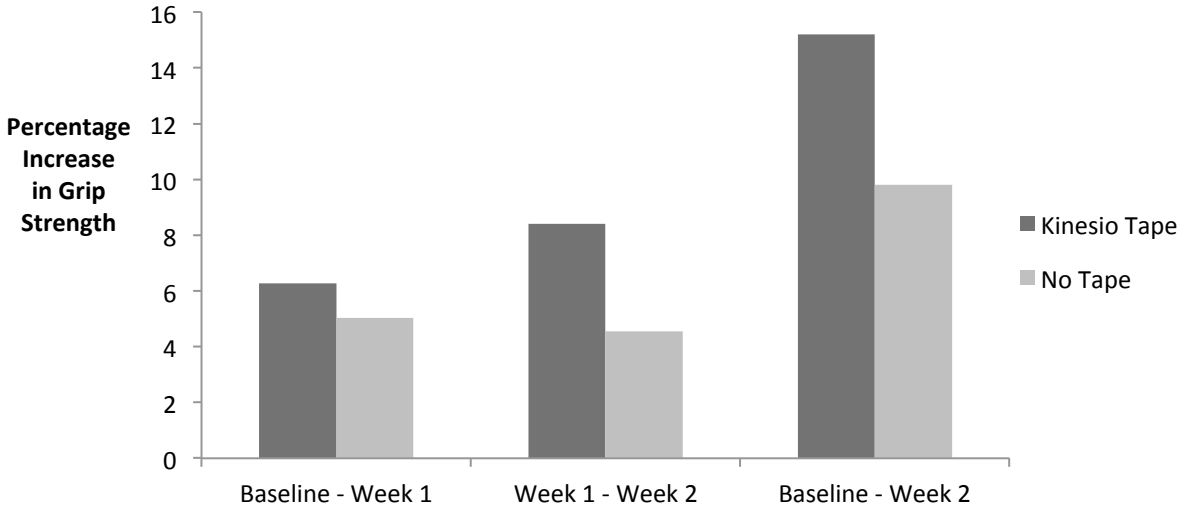


Figure 7. The percentage increase in grip strength for dominant (Kinesio® Tape) and non-dominant (no tape) arms between the three grip strength readings (n = 32).

In the dominant arm (with Kinesio® Tape), the percentage increase in grip strength increased at a greater rate than the non-dominant arm. Between the baseline and Week 1, the dominant arm increased by 6.28% compared to the non-dominant arm at 5.03%. In the second week of the study, the dominant arm increased by 8.40% compared to the 4.55% of the non-dominant arm. Overall, the grip strength of the dominant arm increased by 15.20% compared to the 9.8% of the non-dominant arm.

Table 1. T-Test values and descriptive statistics for the three pairs (Pair 1: Difference between Dominant Week 1 and Dominant Baseline vs. Difference between Non-Dominant Week 1 and Non-Dominant Baseline; Pair 2: Difference between Dominant Week 2 and Dominant Week 1 vs. Difference between Non-Dominant Week 2 and Non-Dominant Week 1; Pair 3: Difference between Dominant Week 2 and Dominant Baseline vs. Difference between Non-Dominant Week 2 and Non-Dominant Baseline).

Paired Samples Test

		Paired Differences			df	Sig. (2 Tailed)
		Mean	Std. Deviation	Std. error Mean		
Pair 1	Baseline – Week 1	0.750	3.360	0.594	31	0.216
Pair 2	Week 1 – Week 2	1.938	3.407	0.602	31	0.003
Pair 3	Baseline – Week 2	2.688	4.768	0.843	31	0.003

Table 2. Grip strength increase separated by gender in PSI (male, n=16; female, n=16).

	Male		Female	
	Dominant	Non-Dominant	Dominant	Non-Dominant
Increase BL-Wk1	2.50	1.875	3.188	1.875
Increase Wk1 - Wk2	3.875	2.188	1.563	0.625
Increase BL-Wk2	6.375	3.375	4.75	2.50

Table 3. Percent increase in grip strength separated by gender (male, n = 16; female, n=16).

	Male		Female	
	Dominant	Non-Dominant	Dominant	Non-Dominant
Increase BL-Wk1	4.860	2.571	10.386	6.772
Increase Wk1 - Wk2	7.184	4.617	4.612	2.114
Increase BL-Wk2	12.393	7.307	15.478	9.029

Table 4. Average Baseline, Week 1, and Week 2 grip strength measurements in PSI separated by gender (male, n = 16; female, n=16).

	Male		Female	
	Dominant	Non-Dominant	Dominant	Non-Dominant
Baseline	51.4375	46.1875	30.6875	27.6875
Week 1	53.9375	47.375	33.875	29.5625
Week 2	57.8125	49.5625	35.4375	30.1875

Discussion

4.1. Discussion:

The purpose of this study was to examine the long-term effects of Kinesio® Tape on grip strength when paired with an exercise program. The initial hypothesis was that when paired with an exercise program, the strength gains of the arm with Kinesio® Tape would be significantly greater than the arm without tape. The hypothesis was supported by the data.

The first analysis was the comparison of the increase in grip strength for the dominant (with Kinesio® Tape) and non-dominant arms from the baseline to the end of Week 2. The results indicated that there was a significant increase ($p = 0.003$, $df=31$) in the grip strength of the dominant arm when compared to the non-dominant arm between the two time periods (Table 1).

A larger percentage increase in grip strength was observed between Week 2 and Week 1 than Week 1 and the Baseline reading (Figure 6). In order to further examine this increase, additional Paired Sample T-Tests were performed. As seen in Table 1, the test indicated that the first week by itself did not yield significant results ($p > 0.05$, $df=31$), but the difference between Week 1 and Week 2 did yield significant results ($p < 0.05$, $df=31$). The difference between the two weeks could be the different resistance of Theraputty used in the exercise programs. The extra-extra soft Theraputty used in Week 1 exercises may not have been rigorous enough to cause a significant increase in muscle strength, but with the increased resistance in Week 2, a significant difference was observed.

There are many studies that found that Kinesio® Tape does not significantly increase muscle strength (Fu et al., 2008). An important difference between this study and previous studies is that Kinesio® Tape was worn throughout the full duration of the study. Most studies that investigated the effects of Kinesio® Tape on grip strength asked participants to wear Kinesio® Tape only for the time of the study. In this study, taping instructions were followed as recommended by Kase et al. where Kinesio® Tape was worn for approximately 4-5 days, and reapplied as necessary. Unlike Chang et al. (2010) the present study examined the long-term effects on muscle strength following application of Kinesio® Tape. Although the taping techniques were identical in the two studies, results from this study indicated that a longer period of application with an exercise program significantly increases muscle strength. This finding is consistent with the results of Slupik et al., who reported that Kinesio® Tape application to the vastus medialis showed a significant produced in bioelectric muscle activity 24-72 hours after initial application.

The results reported here are also consistent with the findings of Vithoulk et al., who reported a significant increase in peak torque during eccentric isokinetic exercise of the quadriceps muscle with Kinesio® Tape when compared to a placebo taping and to no taping. Hsu et al. also investigated the effect of Kinesio® Tape on the strength of the lower trapezius among baseball players with shoulder impingement. The results indicated a trend that Kinesio® Tape increased the strength of the lower trapezius when compared to a placebo taping.

When analysis was conducted regarding the grip strength increases between the two genders, it was observed that there was a larger percent increase amongst female participants than in male participants between the baseline reading and week 2 reading (Table 3). The

average grip strength of females was approximately 20 PSI less than that of males (Table 4). This difference in baseline grip strength measurements could account for the greater percentage increase calculated for the female participants. An interesting point to note is that male participants increased their overall grip strength by an average of 6.375 PSI in the dominant arm and 3.375 PSI in the non-dominant arm, while it was observed that female participants increased their overall grip strength by 4.75 PSI and 2.5 PSI respectively.

When the grip strength increases of males and females were compared, results indicated that there was no significant increase difference between the two genders ($p > 0.05$, df=15). The differences were tested in order to assess the efficacy of Kinesio® Tape for both female and male populations, and the results indicated that Kinesio® Tape that there should not be a difference in effect for the two genders.

A survey of occupational therapists indicated that 98% of practitioners (occupational therapists and certified occupational therapy assistants) were not certified by the Kinesio® Taping Association and lack of training was cited as the main reason for not using Kinesio® Tape in their profession. This same study also examined the settings in which Kinesio® Tape is being used by occupational therapists and results showed that Kinesio® Tape is most commonly used in acute care and outpatient rehab (Smith, 2010). The results of this study now provide statistical evidence that was missing or not widely examined in the area of Kinesio® Tape is increasing muscle strength. This opens doors for Kinesio® Tape to be utilized in training regiments, including weight training and as a general exercise supplement, in which it has not been utilized in the past.

4.2. Clinical Application:

Based on the results of the current study, Kinesio® Tape significantly increased grip strength when paired with an exercise program. This result is of importance for competing athletes, rehabilitation clinics, and physical therapy. Kinesio® Tape could be used in the physical therapy and rehab setting to expedite recovery and restoration of muscle strength following surgical operations, injury, muscle atrophy, temporary weakness/paralysis, and cases of pediatric neuromuscular disorders (Yuwasaka et al., 2006). Future studies of Kinesio® Tape may involve applying Kinesio® Tape on populations with pre-existing conditions or on injured populations to properly assess Kinesio® Tape's accelerated rehabilitation qualities.

4.3. Limitations:

There were some minor complications that arose during the course of the study. The biggest issue may have been getting participants to complete their exercise routines in a relatively normal schedule every week, such that exercises sessions were spread out evenly. Participants weren't mandated to perform the exercise routine on a specific day each week, so some completed all three exercise sessions early/late in the week and some throughout. This caused variation in the recovery times each participant was allowed following each exercise session. However, in a study by Leyk et al., participants were asked to perform an "exhausting manual stretcher carriage," and full recovery time after complete forearm exhaustion was reported as being greater than 24 hours. Given that the exercise routine itself was not rigorous and designed to be rehabilitory, full recovery time following each exercise session was estimated to be approximately 4-8 hours.

Another source of error could have been the difficulty research subjects had using the JAMAR Hydraulic Hand Dynamometer. Even with practice trials at each grip strength measurement, the variance in grip strength measurements (the average was taken for final results) indicated that it was difficult for most participants to perform consistently.

Kinesio® Tape was applied to each of the participants and each participant was told to report to a researcher when the Kinesio® Tape applied to his/her forearm was starting to lift from the skin. A new application of tape was applied when necessary, but it was often difficult to replace tape immediately after adhesion loss. Although this was the case, there were no reports of Kinesio® Tape separating from skin within 4-8 hours of an exercise session. Given the timetable, this would be sufficient time for both the taped and no-tape arms to fully recover.

The findings of this study can only be generalized to populations between the ages of 16 and 23 with healthy to athletic (collegiate athletes) lifestyles. Approximately 75% of the participants also participated in a collegiate sport, which may have also had their own exercise regiments. The participants in this study were not monitored during the times outside of the experiment, and therefore it cannot be known if the participants maintained their normal activity.

The methodology of the experiment could have been improved to increase the accuracy of the results. Monitoring of the subjects would be difficult in any setting for a period of two weeks, but ideally this would be possible. The immediate application of Kinesio® Tape following separation from skin and establishing an evenly spaced schedule between exercise sessions would enhance the accuracy.

4.4. Further Research:

Further research should focus on a longer timetable and also should include a different and/or more challenging set of exercises. Research should emphasize examining the effects of longer application periods and should study application periods upwards of a few months. A larger group study may also be recommended for clinical research. It is also recommended that researchers implement a hand dynamometer that causes less variance in the grip strength measurements. It could also be beneficial to perform this study with subjects who have had forearm injuries within the past three months, allowing the therapeutic effects to stand out more. This research should also be made muscle specific to include muscles other than just the common wrist flexor.

Conclusion

It can be concluded that performing a sufficiently difficult exercise routine with Kinesio® Tape worn for an extended duration (4-5 days) will increase muscle strength more effectively than the same exercise routine alone. This study has demonstrated that it would be beneficial to supplement current established exercise programs with Kinesio® Tape. This study has also shown that Kinesio® Tape is equally effective for both males and females.

The exact mechanism behind this particular effect of Kinesio® Tape is yet to be fully understood, but this study has verified the claim that Kinesio® Tape effectively increases muscle strength. Further research is necessary to completely understand the short-term and long-term effects of Kinesio® Tape on muscle strength. The results suggest that Kinesio® Tape would be useful in the physical therapy and rehabilitation settings as well as in the treatment of acute musculoskeletal injuries. Current statistics regarding Kinesio® Tape use in these settings indicate that Kinesio® Tape is used only in a small percentage of clinics. This study has provided evidence for a claim that has previously been scrutinized and now opens doors for Kinesio® Tape to be used in a revolutionary muscle building method.

Acknowledgements

I would like to thank Steve Graves (CMS Athletics) and Dr. David Hansen (KSD) for their support and valuable guidance throughout this entire process. Thank you to Craig Harnetiaux and Raechel Holmes for your patience with me as well as all of the participants throughout the study. I gratefully acknowledge the assistance of all of the participants from the Claremont College community. I would also like to especially thank the CMS Men's & Women's Tennis Teams for comprising a majority of the participants. Thank you to University of La Verne Kinesiology Department for letting me use their handheld Dynamometer. Thank you to Kathy Troxel for granting me access to the CMS Athletic Training room for my after-hour needs. Thanks to Nikki Gettu for letting me take pictures of your forearm and use them for this paper and poster.

References

Bohannon RW. 1986. Test-retest reliability of hand-held dynamometry during a single session of strength assessment. *Physical Therapy*.

Bragg, R. W., Macmahon, J. M., Overom, E. K., Yerby, S. A., Matheson, G. O., Carter, D. R. 2002. Failure and fatigue characteristics of adhesive athletic tape. *Medicine & Science in Sports & Exercise*. 34(3), 403–410.

Bourke-Taylor, H. 2003. Melbourne Assessment of Unilateral Upper Limb Function: Construct validity and correlation with the Pediatric Evaluation of Disability Inventory. *Developmental Medicine and Child Neurology*.

Callaghan, M. J., Selfe, J., Bagley, P. J., & Oldham, J. A. 2002. The effects of patellar taping on knee joint proprioception. *Journal of Athletic Training*. 37(1), 19–24.

Chang H-Y., Chou K-Y., Lin J-J. 2010. Immediate effect of forearm Kinesio taping on maximal grip strength and force sense in healthy collegiate athletes. *Physical Therapy in Sport.*

Dye S., Staubli H., Biedert R., Vaupel G. 1999. The mosaic of pathophysiology causing patellofemoral pain: therapeutic implication. *Operative Techniques in Sports Medicine*.

Ernst G., Kawaguchi J., Saliba E. 1999. Effect of patellar taping on knee kinetics of patients with patellofemoral pain syndrome. *Journal of Orthopedic Sports and Physical Therapy.*

Fu TC., Wong AM., Pei YC., Wu KP., Chou SW., Lin YC. 2008. Effect of Kinesio Taping on Muscle Strength in Athletes-A pilot Study. *Journal of Science Medicine Sport*.

Grelsamer, R. P., & McConnell, J. 1998. The patella: A team approach. Gaithersburg, MD: Aspen.

Hsu YH., Chen WY., Lin HC., Wang WTJ., Shih YF. 2009. The effects of taping on scapular kinematics and muscle performance in baseball players with shoulder impingement syndrome. *Journal of Electromyography and Kinesiology*.

Kase, K., Wallis, J., & Kase, T. 2003. Clinical therapeutic applications of the kinesio taping method. Tokyo, Japan: Ken Ikai Co. Ltd.

Leyk, D., Rohde, U., Erley, O., Gorges, W., Essfeld, D., Erren, TC., Piekarski, C. 2007. Maximal manual stretcher carriage: Performance and recovery of male and female ambulance workers. *Ergonomics 50*.

Macgregor K., Gerlach S., Mellor R., Hodges PW. 2005. Cutaneous stimulation from patella tape causes a differential increase in vasti muscle activity in people with patellofemoral pain. *Journal of Orthopedic Research*. 23: 351-8.

Murray H: Effects of Kinesio taping on muscle strength after ACL-repair. [http://www.kinesiotaping.com/]. 2001 [cited April 2, 2014]

Murray, H., & Husk, L. 2001. Effect of Kinesio Taping® on proprioception in the ankle. *Journal of Orthopedic Sports Physical Therapy*.

Nosaka, K. 1999. The effect of Kinesio Taping® on muscular micro-damage following eccentric exercises. Kinesio Taping International Symposium Review. (pp.70- 13)

Powers C., Landel R., Sosnick T., Kirby J., Mengel K., Cheney A., Perry J. 1997. The effects of patellar taping on stride characteristics and joint motion in subjects with patellofemoral pain. *Journal of Orthopedic Sports and Physical* Therapy.

Randall, M. J., Johnson, L. M., & Reddihough, D. S. 1999. The Melbourne Assessment of Unilateral Upper Limb Function. Melbourne: Royal Children's Hospital, Melbourne.

Schneider, M., Rhea, M., and Bay, C. 2010. The effect of kinesio tex tape on muscular strength of the forearm extensors on collegiate tennis athletes. *Kinesiotaping*.

Smith, E. The Use of Kinesio® Taping in Occupational Therapy. 2010.

Slupik A., Dwornik M., Bialoszewski D., Zych E. 2007. Effect of Kinesio Taping on Bioelectrical Activity of Vastus Medialis Muscle. Preliminary Report, *Orthopedic Trauma and Rehabilitation*. 644-651.

Talbott, C. (2008, September 19). After Olympic exposure, kinesio tape sticks around. The Associated Press. Retrieved from http://nbcsports.msnbc.com/id/26781777

Vithoulka I., Beneka A., Malliou P., Aggelousis N., Karatsolis K., Diamantopoulos K. 2010. The effects of Kinesio taping on quadriceps strength during isokinetic exercise in healthy non-athlete women. *Isokinetic Exercise Science.*

Yasukawa A., Patel P., Sisung C. 2006. Pilot study: investigating the effects of Kinesio Taping in an acute pediatric rehabilitation setting. *American Journal of Occupational Therapy*.

Zajt-Kwiatkowska J., Rajkowska-Labon E., Skrobot W., Bakula S., Szamotulska J. 2007. Application of Kinesio Taping for Treatment of Sports Injuries. *Research Yearbook*.

Appendix A

Claremont McKenna College

Informed Consent for Participants in Research Projects Involving Human Subjects

Title of Project: The Effect of Long-term Kinesio Taping on Maximal Grip Strength with Exercise.

Investigators: Neel Kotrappa, Steve Graves ATC, Dr. David Hansen

Purpose of This Research/Project:

You are invited to participate in a study on the effects of Kinesio Tape on maximum grip strength. From the information collected and studied in this project we hope to learn more about the effects of Kinesio Tape on increasing maximum grip strength.

Procedures:

Kinesio Tape will be properly applied to the dominant arm of each participant. On Day 1, the participant will provide baseline samples of grip strength, of each arm, measured by a Handheld Dynamometer. Following the measurement, the participant will begin a strengthening program under the supervision of a certified athletic trainer. Theraputty will be used as the main exercise. The participants will completely squeeze the Theraputty with one hand, and release completely. They will perform 3 sets of 15 squeezes with each arm. The participants will return to the research site three times during the week to perform these exercises. The participant will follow this routine for two weeks, each week increasing the consistency of the Theraputty, therefore increasing the resistance felt by the participant. After each week of exercise, the participant will provide grip strength measurements for each arm. Kinesio Tape will be reapplied as necessary throughout the process.

Risks:

There should be no more than minimal risk to you from participating in this study. The risk from using the Kinesio Tape include:

- Skin reaction to the tape, it is important to note that the tape is Latex Free.
- Skin breakdown from tape application.
- Local hair loss may occur when removing the tape.

Only researchers will have access to the final data, and you can refuse to be part of the study. You can also stop at any point during the study. Your results will never be shared with your athletes or coaches.

Benefits:

You may receive direct benefit from this study. We cannot and do not guarantee that you will receive any benefits from this study.

Extent of Anonymity and Confidentiality:

At no time will the researchers release the results of this study to anyone other than individuals working on this project without your written consent.

It is possible that the Institutional Review Board (IRB) may view this study's collected data for auditing purposes. The IRB is responsible for the oversight of the protection of human subject's involved in research.

Compensation:

You will be paid $5 for your participation in this study.

Subject's Responsibilities:

I voluntarily agree to participate in this study. I have the following responsibilities:

- Report to my test sessions on time.
- Report to each test session as scheduled.
- Complete all necessary exercises as described to me by the investigator.
- Complete the testing as described to me to by the investigator.

Freedom to Withdraw:

Your decision whether or not to participate in this study will not affect medical care. Your decision to participate or not participate has no connection to your participation on your athletic team. If you read this form and have decided to participate in this project, please understand your participation is voluntary and you have the right to withdraw your consent or discontinue your participation at any time without penalty. Your identity will not be disclosed in any published and written material resulting from the study.

By signing below, you indicate that you have read and understood the informed consent and conditions of this project, that you have had all of your questions answered, and that you give your voluntary permission for your child to participate in this project. You will be offered a copy of this form

_____ _____

Subject signature Date

Investigators:

Neel Kotrappa	(909) 706-2050	nkotrappa14@cmc.edu
Steve Graves ATC	(909) 607-3248	steve.graves@cms.claremont.edu
Dr. David Hansen	(909) 607-2565	dhansen@kecksci.claremont.edu

Appendix B

Claremont McKenna College

Parental Permission for Child's Participation

Title of Project: The Effect of Long-term Kinesio Taping on Maximal Grip Strength with Exercise.

Investigators: Neel Kotrappa, Steve Graves ATC, Dr. David Hansen

Purpose of This Research/Project:

You are invited to participate in a study on the effects of Kinesio Tape on maximum grip strength. From the information collected and studied in this project we hope to learn more about the effects of Kinesio Tape on increasing maximum grip strength.

Procedures:

Kinesio Tape will be properly applied to the dominant arm of each participant. On Day 1, the participant will provide baseline samples of grip strength, of each arm, measured by a Handheld Dynamometer. Following the measurement, the participant will begin a strengthening program under the supervision of a certified athletic trainer. Theraputty will be used as the main exercise. The participants will completely squeeze the Theraputty with one hand, and release completely. They will perform 3 sets of 15 squeezes with each arm. The participants will return to the research site three times during the week to perform these exercises. The participant will follow this routine for two weeks, each week increasing the consistency of the Theraputty, therefore increasing the resistance felt by the participant. After each week of exercise, the participant will provide grip strength measurements for each arm. Kinesio Tape will be reapplied as necessary throughout the process.

Risks:

There should be no more than minimal risk to you from participating in this study. The risk from using the Kinesio Tape include:

- Skin reaction to the tape, it is important to note that the tape is Latex Free.
- Skin breakdown from tape application.
- Local hair loss may occur when removing the tape.

Only researchers will have access to the final data, and you can refuse to be part of the study. You can also stop at any point during the study. Your results will never be shared with your athletes or coaches.

Benefits:

You may receive direct benefit from this study. We cannot and do not guarantee that you will receive any benefits from this study.

Extent of Anonymity and Confidentiality:

At no time will the researchers release the results of this study to anyone other than individuals working on this project without your written consent.

It is possible that the Institutional Review Board (IRB) may view this study's collected data for auditing purposes. The IRB is responsible for the oversight of the protection of human subject's involved in research.

Compensation:

You will be paid $5 for your participation in this study.

Subject's Responsibilities:

I voluntarily agree to participate in this study. I have the following responsibilities:

- Report to my test sessions on time.
- Report to each test session as scheduled.
- Complete all necessary exercises as described to me by the investigator.
- Complete the testing as described to me to by the investigator.

Freedom to Withdraw:

Your decision whether or not to participate in this study will not affect medical care. Your decision to participate or not participate has no connection to your participation on your athletic team. If you read this form and have decided to participate in this project, please understand your participation is voluntary and you have the right to withdraw your consent or discontinue your participation at any time without penalty. Your identity will not be disclosed in any published and written material resulting from the study.

By signing below, you indicate that you have read and understood the informed consent and conditions of this project, that you have had all of your questions answered, and that you give your voluntary permission for your child to participate in this project. You will be offered a copy of this form

_____

Child's Name

_____ _____

Parent's signature Date

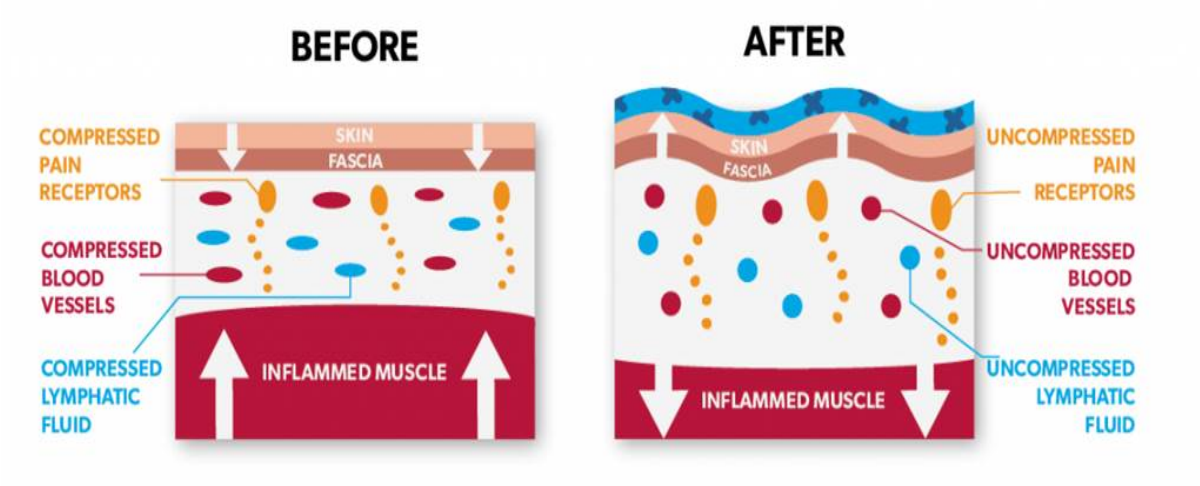
Investigators:

Neel Kotrappa	(909) 706-2050	nkotrappa14@cmc.edu
Steve Graves ATC	(909) 607-3248	steve.graves@cms.claremont.edu
Dr. David Hansen	(909) 607-2565	dhansen@kecksci.claremont.edu

Appendix C

Claremont McKenna College

How Kinesio® Tape Works to Reduce Inflammation in Muscles



Appendix D

2.0 oz. Theraputty™ Used in Exercise Program for Week 1 & Week 2

Theraputty™ Used in Week 1 Exercises

Theraputty™ Used in Week 2 Exercises

Appendix E

Claremont McKenna College

Exclusion Criteria for Participants (All Ages)

Please check those questions to which you answer yes (leave the others blank).

- ☐ Have you had an elbow ligament Injury?
- ☐ Have you had any elbow or wrist injury?
- ☐ Have you ever had tendonitis in your elbow or wrist?
- ☐ Have you participated in a forearm strengthening program in the past 3 months?
- ☐ Do you currently feel discomfort in the Wrist extensors or wrist flexors (Image 1)
- ☐ Do you experience discomfort while making any of the movements below? (Image 2)
- ☐ Have you fractured your arm within the past 3 months?
- ☐ Have you had any nerve injuries within the past 3 months?

Image 1.

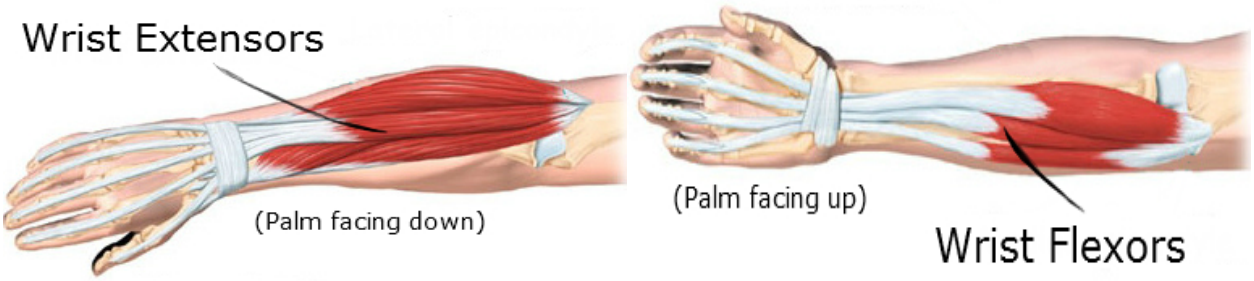
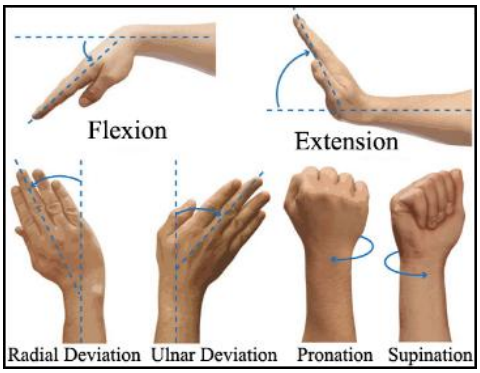


Image 2.



If you answered yes to any of the questions above, you may not participate in this study. This study has been designed to only examine the effects of Kinesio® Tape on a population without previous training and without any wrist/elbow pathology. Thank you for your willingness to participate in this study.

Appendix F

Claremont McKenna College
IRB Approval

Institutional Review Board
Dear Neel Kotrappa,

Thank you for submitting the following research project for IRB **review**:

Research Title	The Effect of Long-term Kinesio Taping on Maximal Grip Strength with
IRB Protocol #	2014-03-036
Principal	Neel Kotrappa
Faculty Sponsor	David Hansen
Approval Type	Expedited
Approval Date	3/10/14
Expiration Date	3/10/15
Notes/Other	Per the CMC survey policy any investigator who wishes to recruit CMC students in person on campus or via email must obtain permission from the VP for Student Affairs.

Your submission has been approved as indicated above.

Noted Policies

- No subjects may be involved in any study procedure prior to the IRB approval date or after the expiration date.
- All unanticipated or serious adverse events must be reported to the IRB within 5 days.
- All protocol modifications must be IRB approved prior to implementation unless they are intended to reduce risk. This includes any change of investigator, or site address.
- All protocol deviations must be reported to the IRB within 5 days.
- All recruitment materials and methods must be approved by the IRB prior to being used.

It is the responsibility of the PI (and sponsor, when applicable) to maintain compliance with these policies and to initiate proceedings with the CMC IRB when changes or unanticipated events do occur.

Please visit www.cmc.edu/IRB for more information on CMC IRB policies and procedures.

If you have any questions or concerns, please do not hesitate to contact the CMC IRB at IRB@cmc.edu.

Appendix G

Claremont McKenna College

Claremont College Mass Invite Message Through Email/Facebook

Hey Everyone!!

I'd love for all of you to participate in my senior thesis project!! I'm running an experiment that examines whether or not Kinesio Tape (the tape worn by Olympic Athletes and other professionals) is effective in increasing grip strength when paired with an exercise program.

The experiment itself lasts three weeks, and everyone who participates would be required to do the following:

1) Wear Kinesio-Tape for the duration of the study on the dominant forearm
2) Come to the CMS Athletic Trainers 3 times a week to do the strengthening program (max 10 minutes)
3) Let me know if the KT-Tape is coming off, so I can reapply a new one.

The amount of involvement may seem like it's a lot, but each exercise session takes less than ten minutes, and you can do it on your own schedule 3 times during the week. You'd just have to go to the trainers during normal business hours.

At the end of the study, everyone who participates will receive a small form of compensation in the form of an In-n-Out gift card.

Please let me know as soon as possible whether or not you will be able to be a part of this experiment! I'd love to get as many people as possible, so invite your friends also! Thanks and see you soon!!

Thanks!!

Neel Kotrappa
Nkotrappa14@cmc.edu
(909) 706 - 2050